SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE OFFICIAL NOTICES AND PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

FRIDAY, SEPTEMBER 19, 1902.

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MSS. intended for publication and books, etc., intended for review should be sent to the responsible editor, Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

RUDOLF VIRCHOW'S ANTHROPOLOGICAL WORK.

IN Rudolf Virchow science has lost one of its great leaders, Germany one of her great citizens, the world one of its great men. For sixty years Virchow has devoted his strong mind and his indefatigable energies to advancing the work of mankind. The science of medicine, anatomy, pathology and anthropology count him as one of their great men. For long years he has been a power in German political life, always upholding the cause of personal freedom.

The beginnings of his anthropological work almost coincide with the beginnings of modern physical anthropology in Germany. Among the men who laid the foundation of this science no one has done more to shape, guide and foster it than Rudolf Virchow. His interest in anthropology, which was destined to impress the mark of his personality upon the young science, developed during the time when he investigated the causes of cretinism and the conditions determining the growth of the skull. The similarities between pathological forms of the skull and those found among different races of man probably led him to researches on the variations of form of the human body. The scope of his anthropological interests expanded rapidly and the impetus which he gave to anthropological work, particu-

larly in physical anthropology and in prehistoric archeology, was so great that the development of these two branches of science in Germany may be said to center in Virchow's activity.

At the time when Virchow took up his work, anthropology was still in its first beginnings. During the eighteenth century Von Sœmmering and Blumenbach in Germany, and Camper in Holland, had directed their attention to a study of the anatomical characteristics of the races of man, but the new anthropology did not arise until the second half of the past century. The strong impetus which the theory of evolution gave to all sciences, combined with the immediate interest in the early history of European nations, and the increasing knowledge of foreign races were the principal factors that contributed to the formation of modern anthropology.

Virchow, through his eminent faculty for organization, has advanced the whole field of anthropology. He took a leading part in the formation of the German Anthropological Society, of the *Berliner Gesellschaft für Anthropologie, Ethnologie und Urgeschichte*, and in the establishment of the monumental *Archiv für Anthropologie* which occupies a high rank in anthropological literature. The two societies soon became the centers of anthropological activity in Germany. The German Anthropological Society devoted its energies to the study of the physical characteristics and of the earliest history of the Germans. Under Virchow's lead this society undertook to collect statistics relating to the distribution of the color of skin, eyes and hair in Germany, and observations were collected in all the public schools of the country. The results of this extended inquiry, which include a cartographic representation of the distribution of types in Germany and a discussion of their probable history, were published by Virchow.

The *Berliner Gesellschaft für Anthropologie, Ethnologie, und Urgeschichte* soon became a center to which flowed a flood of anthropological material from all parts of the world, and where important scientific questions were discussed by the most competent authorities. Through its intimate relations with German travellers the society became of valuable assistance in the development of the Berlin Ethnographical Museum, which owes its origin and greatness to Adolf Bastian. Owing to Virchow's influence the society gradually acquired a large and valuable collection of human crania and skeletons. Among the subjects discussed before the society European archeology always held a prominent place, and Virchow took a lively part in this work which has contributed much to the growth of the prehistoric collections in Berlin.

As director of the Pathological Institute and Museum of the University of Berlin, Virchow had further opportunities to advance our knowledge of the anatomy of races, and he accumulated much valuable anthropological material in this Institute. His studies of prehistoric archeology brought him also into close contact with students of folk-lore and he became one of the founders of the *Museum für Volkstrachten.*

It will thus be seen that Virchow took the leading part in the organization of anthropological work in Germany. Therefore, it is no wonder that his views have wielded a far-reaching influence, so much so, that without a knowledge of his work the peculiarity of German physical anthropology and of German prehistoric archeology can hardly be understood.

Most important is his attitude toward the theories relating to the descent of man. His views regarding this question were determined by his fundamental researches on the functions of the cell in the animal organism. He formulated his views in the

words that every cell is derived from another cell. No matter how much the forms of the cells may vary, every new form is derived from a previous form. Cells, in the course of their lives, may change their forms according to age and according to the influences to which they are subjected. Such changes take place both in the healthy and in the sick organism, and often it is impossible to draw a sharp line between normal or physiological, and abnormal or pathological, changes. Virchow himself expresses these views in the words that in reality there is no distinct line of demarcation between physiological and pathological processes, that the latter are only physiological processes which take place under difficult conditions. The cell which changes its form during its lifetime may, therefore, be said to be variable; or, in Virchow's words, it possesses mutability. From his point of view the whole question of the origin of species centers in the problem of the relation between the mutability of the organism and the mutability of the cell. The comparison of the forms of organisms and organs may form the starting point of researches on variability, but the study of the variations of the whole organism or organ must be based on the study of the variations of the constituent cells, since the physiological changes of the whole body depend upon the correlated physiological changes that take place in the cells. Without a knowledge of the processes that take place in varying cells, it is impossible to determine whether a deviation from the normal form is due to secondary causes that affect during their period of development organs already formed, or if it is due to primary deviations which develop before the first formation of the varying organ.

Two questions, therefore, arise: the first, if secondary deviations may become hereditary. For this no convincing proof has been found. The second question is whether primary variations do occur, and if so, whether they are hereditary.

Led by these points of view Virchow demands that researches on the origin of species be based on researches on the mutability of cells and groups of cells, and he declines to speculate on the origin of species, until through researches on tissues a sound foundation has been laid. Sometimes it would seem as though Virchow doubted the scientific value of the theory of evolution. I do not think this is the case. He merely emphasizes again and again the methodological point of view, that the understanding of the forms of the body must be based on a knowledge of the forms, mutual relations, and functions of the cells and that, therefore, the question of 'mutability' must be settled by researches on these lines.

Furthermore his position rests on the general scientific principle that it is dangerous to classify data that are imperfectly known under the point of view of general theories, and that the sound progress of science requires of us to be clear at every moment, what elements in the system of science are hypothetical and what are the limits of that knowledge which is obtained by exact observation. To this principle Virchow has adhered steadfastly and rigidly, so much so that many an impetuous student has felt his quiet and cautious criticism as an obstacle to progress. On this account he has suffered many hostile attacks—until generally the progress of research showed that the cautious master was right in rejecting the far-reaching conclusion based on imperfect evidence. There are but few students who possess that cold enthusiasm for truth that enables them to be always clearly conscious of the sharp line between attractive theory and the observation that has been secured by hard and earnest work.

There are two anthropological problems which are important in their relation to the

theory of evolution; the one that of the antiquity of man, the other that of the interpretation of anatomical characteristics of the lower races. The evidence in regard to the anatomical form of early man is very scanty, and for many years the discussion centered in the interpretation of the Neanderthal skull, which possesses a number of peculiar characteristics, particularly an exceedingly low head and very large superciliary ridges. Virchow demonstrated that the skull had undergone many pathological changes, and he took the position that it was unsafe to base on this single specimen a new race which might be considered a precursor of man. He preferred to consider the skull as an individual variation until other similar finds would give corroborative evidence. Virchow was equally cautious in the interpretation of theromorphic variations in the forms of the human body. He maintained that such forms are not necessarily cases of atavism, but that they may be due to peculiar physiological processes; and that without special investigation of their origin they cannot be considered as proof of a low organization of the races among which they are found with particular frequency. There is no proof that such forms are connected with a low stage of culture of the people among whom they are found. They occur, for instance, among the Malays and among the ancient Peruvians, both of which races have attained high stages of culture.

We cannot, in the scope of these notes, enter upon Virchow's numerous investigations bearing upon the anatomy of the races of man. Many of them contain discussions of general principles. His researches on the physical anthropology of the Germans and his description of American crania may be mentioned as specially important.

His investigation of the anatomical characteristics of the Germans led him naturally to studies in prehistoric archeology to which he devoted much of his time and energies. For a long time forms of the body were considered a characteristic of nationalities. Forms of skulls were described as Teutonic and Slavic; there were Turanian and many other kinds of skulls. Nobody has done more than Virchow to show that this view is untenable. The question of the history of the Slavic settlement of eastern Germany has received much attention on the part of German archeologists and is still far from being entirely cleared up. While methods of burial, prehistoric objects, names of places, plans of villages and houses are good indications for ancient Slavic settlements, the anatomical forms of the present population and of ancient skeletons do not allow us to draw any inference regarding the nationality of the ancient inhabitants, because neither Germans nor Slavs present a uniform and characteristic anatomical type. Virchow has always maintained that the limits of human types do not coincide with the dividing lines of cultures and languages. People who belong to the same type may speak different languages and possess different forms of culture; and on the other hand—as is the case in Germany—different types of man may be combined to form one nation.

These phenômena are intimately connected with the intricate migrations of the races of Europe; with the invasions of southern Europe by Teutonic peoples and the development of north European culture under the influence of the cultures of the eastern part of the Mediterranean Sea. The gradual introduction of metals and the disappearance of the culture of the stone age is one of the phenomena that are of great assistance in clearing up the relations between the ancient inhabitants of Europe. The change of culture indicated by the introduction of bronze indicates that the new culture arose in the far East. This is the reason which induced Virchow to under-

take extensive prehistoric studies in Asia Minor and in the region of the Caucasus. His studies in prehistoric archeology, which apparently are so remote from his original anatomical work, are in reality closely connected with his researches on the early history of the races of Europe. Anatomical data alone cannot solve these intricate problems, and Virchow's extensive activity in the field of prehistoric archeology is another proof of his thorough and comprehensive method which utilizes all the available avenues toward the solution of a scientific problem.

Physical anthropology and prehistoric archeology in Germany have become what they are largely through Virchow's influence and activity. His method, views and ideas have been and are the leading ones. His greatness as a scientist is due to the rare combination of a critical judgment of greatest clearness and thoroughness with encyclopedic knowledge and a genius for grasping the causal relation of phenomena. His critical judgment was so strong that, in an address delivered in the summer of 1900, he was even led to doubt the desirability of the strong preponderance of his influence upon current opinion. With profound admiration and gratitude we regard his life's work which has determined the course of a new science.

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SCIENTIFIC RESEARCH: THE ART OF REVELATION AND OF PROPHECY, II.

XI.

Collaboration of all sciences, physical and metaphysical, must ultimately be the task of the investigator and the end of research. The several sciences are the formulated expressions of nature's law of a universe, and all are functions of force, movement, energy, of life and its material foundations. To discover the relations of the sciences and to reduce them all to departments of one all-comprehending system will prove, if it can be achieved, the highest result of research. Already, the thermal, luminiferous, electrical, mechanical, chemical, and to a certain extent the biological, sciences are known to be divisions of the more comprehensive science of energetics; all treat of manifestations of energy and its conversion from form to form and its transfer from point to point. Already it is known that other manifestations of force and energy, if not still-disguised illustrations of familiar forms, are existent in the animal machine, and it is suspected by some, believed by others, admitted to be possible by yet others, that those energies which pervade the more ethereal atmospheres, the vital and perhaps other energies, are transformations of the familiar kinds. The question has even been seriously and honestly asked whether spiritual life and energies may not have definite relations of quantity, and even of transformability, with those characterizing the physical world. Vital energy, moral force, the efforts of genius, exhibit themselves in the individual in larger or lesser degree as his supply of potential energy in form of food varies from excess to deficiency and as his physical powers fluctuate.

Are there two universes, the seen and the unseen? How is the seen related to the unseen? Are there definite quantitative equivalences among the forces and the energies of the one and of the other? What are these equivalences among the energies of the unseen, if they exist, and what the facts and laws, the algebraic statements of law, and the values of the constants representing facts at the points, the surfaces, of junction?

These and other questions constitute problems for the coming investigator, familiar with the phenomena of the seen and

the unseen. Their solution will, if proved possible and practicable, furnish the elements of the Universal Science of Energetics for all these worlds.

Over ten years ago, addressing the Alpha Chapter of Sigma Xi, I took occasion to refer to the still unsolved problems of this nature.* These problems have been solved, here and there, and occasionally a great step has been made, as when the divisibility of the so-called atom of the chemist was shown to be possible, or where wireless telegraphy has become practicable; but the impression made during these ten years upon the great body of the unknown has been comparatively small, and the opportunities for further revelation and the scientific use of the imagination, of scientific prophecy, are larger than ever.

Unquestionably there exist energy relations amongst all phenomena of motion, relations of potential energy amongst all groupings of atoms, molecules and masses. The fundamental law of energetics is already known, as is the law of the quantivalence of all the energies, and as is the fact of the persistence of energies and of matter. It needs but the discovery of the mechanism of matter and of motion, and of its action in production and transfer of energy-effects, to furnish the essentials for the establishment of a complete and universal science of the material universe as we know it. We may even perhaps hope to enter at least the borders of the unseen universe, now apparently closed to us. But we have studied and weighed and measured the unseen atom and molecule; we have discovered the movement of unseen particles as ions; we have even determined the size, form and orbit of an unseen stellar world: why should we despair of ultimately finding ways of tracing the laws and the phenomena of the grander Unseen? Cicero's declaration becomes more convincing as the years go by and as science becomes more easy of comprehension and more nearly all-comprehending.

* 'The Man of Science, his Methods and his Work,' address before the Alpha Chapter of Sigma Xi, Cornell University, June 14, 1891. *Scientific American Supplement*, January 2, 1892, No. 835.

XII.

A later Newton, Galileo, Bacon or Compte, with learning sufficient to perceive the relations of the fundamental facts and laws of allied sciences, possibly comprehending the common features of all natural science, will find here the greatest of opportunities for the greatest of all great minds. The progress of the sciences, individually, is continuing to exhibit gain in rate of gain; the boundary between chemistry and physics, between both, and applied mechanics, between all phases of nature and all movement, is constantly becoming more and more obscured. The time is evidently steadily approaching when chemistry and physics will have a common and smoothly shaded, if not obliterated, junction, when energetics will comprehend all phenomena, and all laws of mass and molecular and atomic motion, alike. Mighty minds will certainly come forward, in due time, each familiar with the learning of each of a pair of divisions having thus adjacent limits, to join the two sections together with a perfect and indistinguishable weld. With our present knowledge of the tendency toward the simplification and the union of the sciences, it is even possible to imagine the appearance, at some future day, of minds capable of thus reducing to continuity and unity the whole area. There is the more reason for conviction that such a result may be sometime attained as we realize the fact that it is through such unity and conspiring of the forces and the laws of the universe that nature accomplishes her great purposes and that man must, by similar extension and union of his codes of

scientific law and his use of forces and energies, attain the solution of the greatest of the problems now confronting him.

Scientific research is only just beginning to be appreciated and to be understood, even by those engaged in the great work. The 'scientific method of advancement of sciences,' as I have elsewhere called it,* is hardly yet beginning to be fully recognized as a method to be developed and formally and systematically promoted. The organization of the Smithsonian, the later foundation of the Carnegie Institution, and the administrations of the scientific associations generally, are hardly yet beginning their real work—that of placing this fundamental basis of all scientific research on its proper and only correct footing. The organization of laboratories for research is only just beginning to be recognized as the real economic foundation of all human progress in scientific and industrial fields. Here and there a great mind is now coming to see the opportunity that thus offers for investment of capital in a manner most fruitful and productive of return to the world. Hereafter this revelation of the scientific method of the promotion of science will find many Carnegies to promote the work thus pioneered.

The perfected pantology, seen from afar by a few great souls, known already in some details by men of genius, will take form, as time passes, by the gradual collaboration of science with science and of congeries of sciences with other aggregations, indefinitely. The trend is already definite and the progress made, during the nineteenth century alone, has been enormous. Its rate has been and still remains an acceleration.

XIII.

The progress of a nation, the progress of the world of civilization, is coming to be seen to be dependent upon the advancement of science by deliberate, scientific, wise planning of investigation by learned men, each in his chosen department. The study of 'Curves of Progress'* of all the various departments of human knowledge and of all the material movements of modern life, can now be seen to promise the revelation of new facts, their groupings to illustrate, graphically, usually, the underlying law, and to permit the prophecy of future progress and its essential and controlling conditions. The comparison of the trend of the various curves of progress of intelligence, of production of trained and cultured men, of the steel and the iron manufactures, of accumulation of wealth, of advances in earning power of producers, of the development of a material civilization and of the highest civilizations, shows very clearly the fact of a correspondence amongst them all in method and rate, and of acceleration of advance, and reveals the law that all progress must be traced to the more or less scientific development of universal application of scientific methods of advancement of science.

The graphical representation of the statistics of Mulhall, which I employed in the first illustrations, the similar exhibition of the constant growth of production, as, for example, in the copper industry,† may be used to exhibit the universal fact that all real progress, materially, involves the extension of a market and the steady and accelerated growth of production, with synchronous increase in the efficiency of methods of production through invention and improved methods, the equally steady rise in wages of producers availing themselves of such improvements in the art, and the steady decrease of costs and prices as meas-

* Vice-President's address before the American Association for the Advancement of Science, 1878, St. Louis meeting.

* 'The Trend of National Progress,' *North American Review*, September, 1895.—R. H. T.

† 'The Modern Law of Supply and Demand,' SCIENCE, December 4, 1896.—R. H. T.

ured by the buying power of the wage of the worker. As I have somewhere said:

"The world has made greater progress in the last century than in all the earlier ages. This progress it owes to the inventor, the mechanic and the engineer. Modern material advancement practically dates from the time of the general recognition of the inventor's rights, and the formulation of the first rough outlines of our modern system of patent law, at the commencement of the seventeenth century. But all progress is an acceleration, and, slow at first, it becomes increasingly rapid, until, after a time, all the world is astounded by its mighty rush."

Morals, manners, culture, develop with the progress of the age and the progress of the age depends upon the advancement of science and the promotion of a material civilization with its concomitants of intelligence, leisure and opportunity, by the development of methods of useful employment of every department of the applied science. The progress which has been made, for example, during the two centuries just past, has been due in large part to general progress in intelligence; progress in intelligence has been due to advancement in education and to that splendid contagion of civilization which comes with increasing contact of class with class and general distribution of the privileges of enlightened civil life. Such forward and upward movements come of the growth of production and that increase in wealth and leisure which allow of the more general distribution of opportunity and of education and of the comforts of civilized life. The foundation of all progress, spiritual, intellectual and material, alike, for the nation always, for the individual usually, is material. Only with aggregation of property and increase in comfort with decreasing hours of labor can liberty be secured for thought and for care of others, for education and for aspiration, and for either moral or material gain. Wealth will demoralize individuals; it may even, with a rude people, stimulate crime and vice; it is yet the fundamentally essential element of human progress, and the nation or the individual taking full advantage of its opportunities and privileges gains in maximum degree in morals, manners and culture.

Among the ancients, a high degree of civilization and a corresponding lofty plane of morals, manners and culture were possible to the few and an aristocracy of intelligence, as of the limited wealth of time, was a natural consequence; but it was not possible to have a satisfactory condition of the people as a whole until they were emancipated by advancing material civilization from the bondage of continuous toil.

Many problems still loom up in the immediate future, and some of them, outside the domain of scientific research as commonly restricted to a definite field and scope, of vastly greater importance than any known unsolved question in scientific departments of physical work. The greatest of problems for civilization, that of an efficient and profitable and generous education of all people upon whom is fixed the responsibility, in however small degree, of self government, and in such manner that the risk to people and to government shall be least, while the opportunities of the youth of the nation shall be the greatest possible in acquirement of wisdom and learning, of knowledge and culture, and of the fundamental principles underlying the best practice in the arts in which they are engaged.

'The modern educations,' as I have called them,* are many in detail, but all are underlaid by the fundamental, scientific, princi-

* 'The Mechanic Arts and Modern Educations.' An address before the Virginia Mechanics' Institute, Richmond, Va., May 18, 1894. *Scientific American Supplement*, November 3, 1894, p. 15,705.

ples which are the essential elements, also, of successful scientific research; the efficient revelation to the growing and maturing mind of the great facts and the principal data of all branches of knowledge or of philosophy proposed to be taught, and this discovery, to the youth of sufficient capacity, of the great laws of nature which relate those facts to one another and to the great scheme of the universe. Finally comes the deduction, from the trend of movements controlled by those laws, of the most direct line of present and future progress and the best methods of promoting, of profiting by, scientific progress in later times. There may be hardly a less exact science of education than of astronomy or geometry or mechanics, and there is but a mathematical line of ideal, perfect advance. Our grandest problem is to find and to follow that line and to show the way to later generations.

We are not called upon simply to ascertain what, for our time, is the most desirable system of school and college work, or even what is the most 'complete and generous,' the most truly Miltonian, education; but rather to discover and reveal the best system of teaching a people what a people should know, effectively and with certainty. This problem being solved, we may reveal the principles and all their corollaries and show the way to 'educate a people for the life and work of the people.' Prophecy then will become simple and certain respecting the ideal educations, and the results of their formulation and introduction by great minds devoted to the greatest of all human tasks in the fields of human knowledge.

XIV.

Revelation and prophecy are thus the characteristics of the work of the scientific investigator and the outcome of research. The revelation of the facts and the laws of the phenomena witnessed in the various kingdoms of nature, their mutual relations, the control of the movements of all cycles, and all progress in the orderly evolution of the natural world, by law, the motions of atoms, changes of compounds, growth and life-histories of creation and its worlds, giving the human mind the power to look back upon the centuries and the ages, is but the first part of the task of science. A prophecy of a future of progress in the infinite evolution, discovering the trend of every continuous movement up to date and indicating the direction of further development, is the second and consequent task. In science, more than in any other department of knowledge, is it possible to judge the future by the past and, as the movements of sun, stars, planets and all satellites may be now predicted by the astronomer, so the evolutions of geology, of botany, of biology, of the races themselves, man and animals, are coming more and more within the purview of the seer. The life-histories of worlds and systems and perhaps of universes are to steadily reveal themselves in coming time. Already it is possible that the long uncertain question of the method of restoration of kinetic energy and all life, within a universe, run down, apparently dead and cold, and whose energies of motion have been converted into potential forms, is beginning to find answer; the significant hint of the new star and the new nebula in Perseus may prove the first of the revelations throwing light upon this immense enigma.

Wherever the path of time may be traced and represented by its 'curve of progress' its terminal in the present may be with certainty projected forward into a future, and prophecy becomes as accurate, approximately, as the line of the immediate past.

It is science only that can read the oracle of the future.

Knowing, from an experience extending far back into the past, that all the phenom-

ena of nature are simply parts of one great movement, each event a consequence of an earlier trend and a natural, necessary and obvious sequence of a next preceding event, it becomes easy to understand that every coming event might be foreseen by an all-comprehending mind, and that even the least learned and the most commonplace among scientific men may predict with certainty within its limits, the man of genius and learning simply having a more extensive range within individual bounds than his fellow.

Certainty and accuracy of these oracles thus are approximated as the conditions are the more simple, the phenomenon the less involved with other sequences, the trend the more definite and the period over which the curve of progress must be extended into the future the shorter. The rise and fall of the tides, the instant of an eclipse, the motions of the companion of Sirius, the form of every definite cycle, may be determined and their future predicted accurately. The growth of a great population, the progress of civilization as measured by growth of manufactures, or by advances in education, or by the gifts of philanthropy, may be traced along a curve of the immediate future, at least approximately. The coming events of the seismic period just reached in the West Indian seas cannot be even approximately predicted. The trend of progress of our own country may be perfectly determined and the future may be as clearly indicated—*provided* no change, catastrophic or other, in the controlling forces which determine its path, meantime, occurs. The astronomer deals with positive and exact prophecy; the economist and statistician must content himself with approximations and probabilities of varying values.

Yet, even the economist and the student of history may declare assent to the following code and, in this general way, reduce economics and history to the form of a science with capacity for prophecy.

1. The laws of social and economic phenomena and movement control all human progress and determine the advance of all nations, and give form to their 'curves of progress' in wealth, education and culture and morals.

2. These laws are found to insure steady progress with acceleration and without much regard to so-called 'crises' or good or bad times.

3. The 'trend of progress' in past decades, for example, in our own country, and this acceleration, constitute a guide in predicting the immediate future of our industrial and social system.

4. This 'curve of progress' being drawn for the past history of the nation, its direction at the moment indicates the certain trend for the immediate future, its probable trend for later dates, and its progress in future decades with a degree of probable approximation which lessens as the remoteness of the time of fulfilment of the prophecy increases.

5. The means and methods of progress are through the steady improvement of the arts and sciences and the constant reduction of the proportion of the working power of the world which is wasted, or at least employed with no permanent effect, with as constant increase in the proportion applied to the increase of our stores of desirable and permanent forms of wealth.

6. Culture, and all desirable things, will come to the nation, in the future, in increasing proportion, so long as the present conditions of production are maintained and a whole nation is kept employed in increasing proportion and with increasing productiveness and with constant gain in the proportion of labor which is applied to the supply of other products than those of immediately perishable character. The less the labor required for production of food-

stuffs, for example, the more becomes applicable to the manufacture of the comforts of life.*

The same simple principles apply to the industries generally and individually, to the advances observed in the economic progress of the arts, to the development of every science. The thermodynamist traces the history of the heat-engines and finds that he may plot a curve of their gain in efficiency, in that of increasing steam-pressures, expansion ratios, speeds of piston and of rotation, 'duties' and even financial returns. He predicts the approximate values of these quantities for the engineer, and the engine-designer and builder know practically what to anticipate in the immediate future and how to modify their designs in the direction of further improvement. The spinning of cotton and the weaving of cloth, even, follow similar general laws and the expert traces the curve of their progress and knows that increasing speeds of rotation of spindle, a more rapid beat of the loom, simplification of mechanism, all tending to make the day's work of the expert operator more productive, will carry out the curve of progress with further and constant tendency to elevation. The superposition of the two curves insures still more rapid rise, and the gain of the Olympia Mill in the South over the most ancient in operation in the North comes thus largely of the fruition of a visible and measurable and steady past progress.

The resultant of all the curves of modern progress in superposition is seen in those of the nation and, studying these, we may assert that given, in the immediate future as in the immediate past, that quiet and peace essential to maximum efficiency of industry, to the maintenance of production on the part of the whole working population, through unintermitted labor with highest skill, through maximum time consistent with a wholesome and healthful life, the trend of national progress will continue onward and upward with further acceleration, even though already far ahead of anything ever before seen in any part of the world. Unimpeded by folly, demagogism or international troubles, our total wealth should at least double each generation; the earnings of the average worker should nominally double each forty years or less, and, measured in buying power, at a much higher rate. The next generation, all going smoothly, will see the average skilled workman enjoying as much of comfort and luxury as the average member of the college faculty to-day, and probably more.

The trend of production of the industrial arts, and especially of those which contribute most to the comfort and pleasure and moral and intellectual profit of the people, will be found to exhibit the most impressive advances, and already the wealth of the country in this form is equal to the total of all our houses and lands—and is increasing at a double rate; which, 'being interpreted,' means that, our necessities being practically fully supplied, our people are now accumulating the comforts of life and all its good things by application to the production of new wealth in these forms an already large and a rapidly increasing proportion of the productive energy and ability of their ablest minds and most highly skilled artisans. Ability, capital and mechanical energy and brute forces are conspiring as never before to give the great body of the people of the United States and, in less degree, of other civilized nations, a large and increasing proportion of the growing product of these three factors of progress. We are fifty per cent. more comfortable than were our people in 1880, sixteen times as comfortable as were our

* 'The Trend of National Progress,' R. H. Thurston, *North American Review*, September, 1895.

parents in 1850, and our children in the rising generation will have twice as many luxuries and live twice as easy and comfortable lives, if they so choose, in their later time as do we to-day.* The oracle may sometimes be in error; but it remains the fact that "science, and science only, often can and frequently does, by a perfectly accurate and correct method, give us clairvoyant views of the immediate, if not of the remote, future. Of the trend of modern progress, in the direction and in rate of movement, there is no reasonable doubt."

XV.

Finally, *en résumé,* to our time,† all life and movement, whether of man, animals, vegetation, seasons, suns and planets, arts, commerce, civilization, intellectual, moral or physical worlds, depend upon transformations of preëxisting energy. All studies, all work in the domain of the physical, the natural sciences, relate to transformations of energies and their mutual interactions and modifications. We have learned to compute the velocity, to determine the methods of refraction and reflection of light; but we still know little of its exact character as motion of molecules. We know the related form, heat-energy, in its sensible effects; but we are still unable to differentiate the one from the other. We can produce and utilize electricity in many ways, but we, as yet, do not even know what it is or how its transformations from other energies are effected. We work with these three forms of power, they are the amusement of the ignorant, the wonder of the sage, the slaves of humanity; but we do not even know what is the nature of the substance through which they act to produce their beautiful, their marvelous, their world-impelling effects. The ether is still to us an enigma, unsolved by the wisest, a riddle to the most expert investigator.

* 'The Trend of National Progress,' Conclusions.

† This section is abstracted from the earlier address already referred to.

The chemist knows much of the composition of 'compounds,' but he has never seen, felt or identified an 'atom' and still vaguely dreams of a single first element into which all shall be resolved. He counts with unseeing eyes the number of atoms in a 'molecule,' but has never yet learned their form or grouping. Even with the aid of the physicist he loses track of their transformations in the furnace of the sun and the stars, and finds in the spectroscopic lines a strange language of which he lacks the key. He can isolate and weigh the phosphorus in a gram of steel, but he cannot give us the phosphorescent fuel, the source of light, of the fire-fly. He can reduce the muscle, fat, and nerve matter of the human system into their elements, but he cannot produce the storage batteries of brain and spine, or the gymnotus' cells.

The astronomer weighs and measures the sun, the moon, the planets, and the nearer stars; but he stands aghast and amazed by that flying sphinx, '1830 Goombridge,' the 'runaway star,' flying 200 miles a second, faster than it could fall from infinite space, and its origin, course, destiny are to him questions of the oracles. He has, as yet, no solution. He is lost amid the depths of space, he knows not where to look for a limit, or how to prove its non-existence. He asks, with the believing and the unbelieving among the simple, How and when shall the 'Heavens melt with fervent heat'? and, How long shall this wandering handful of worlds traverse the infinite safely and without that conflagrating collision with other systems or other worlds that, as it seems possible, now and then, at intervals of years or of centuries, causes a star to blaze out in the midst of darkness with a brilliancy greater than that of the

sun? His little span of life is too short to permit him to follow the evolution of the worlds from their initial nebulæ, too brief to give him access to the secrets of their Maker.

The geologist tells us of the past history of all that lives, and of this spinning globe on which it has found foothold, falling into life from unknown space, and time, and depths; but he cannot tell us whence came all life, whence all spirits, all human and divine souls now constituting its living freight, as it wanders with unguessed destiny through an unmeasured universe. He roughly traces its superficial changes from the day of mist, through the ages of creation and growth of all that has come into life; but he and the physicist and the astronomer are alike uncertain whether it shall endure a thousand million of years or a single day. The physicist predicts a limit of a few million years, the geologist believes many millions, but no man knows when life shall perish from the face of the earth.

The biologist can give microscopic measures and microphotographic pictures of the tissues, and can trace a nerve to its minutest ramifications; but we have yet to learn the secrets of the source of life, of method of production and application of energies, of those transformations that give form, structure, life, and power to the organism of monad or of man. He exhibits the mechanism of the fish, but finds not the secret of separation of oxygen from the medium in which he lives, and cannot produce a submarine vessel. He knows the shape and movement of the bird, but flight remains to him a mystery. He measures the heat of the animal body, but biologist, chemist, physicist and engineer, all together, give us no hint of the method of its production. They know, to an ounce, the power per cubic inch or per pound of the muscle, but neither one nor all can say how that power is originated, how transferred or how exerted by the transmitting threads of working muscle.

The engineer has, for a century, made steady progress in the adaptation of machinery to every purpose of modern life. He converts the potential energy of the vegetable life of a myriad earlier ages into steam power, and applies it to the impulsion of railway carriage, of steamship, and of mill; but, in the process, he wastes four-fifths or nine-tenths of it, and pays out principal where he might, perhaps, pay only interest. He turns the elastic force of expanding steam into an electric current and sends it out to relieve the burden of the overworked horse; but he allows as much to slip from his grasp, often, as he usefully applies to his proposed work. He diverts the energy of combustion or of falling water into the new form, and the electric light, through his genius, gives illumination to street, and dwelling, and hall; but every light ray goes forth to its task carrying with it a sheaf of heat rays; and the glow-worm shames the man, producing light without heat, and heat apart from light, and all researches exhibit only our ignorance and comparative inefficiency. He measures the speed and power of the albatross, the eagle, and the swallow; but he only marvels the more at their beautiful movements and rapid flight. He captures the dolphin and overcomes the whale when they traverse the surface of the ocean, but he knows not how to follow them into the depths of the sea. He crowds his fellows into mills and factories, but sees no way of giving each an individual life and work, comfort and health in equal and fair quantity. The man of science, whatever his chosen task, whatever his field of labor, however high his attainments and whatever the magnitude of his accomplishments, finds that acquisition of learning, gain in knowledge of the ways of nature, increas-

ing appreciation of, and familiarity with, God's ways, only bring to his dazed eyes greater and more novel marvels, grander and wider sweep of opportunity, mightier and mightier mysteries, all challenging him to nobler aspirations, more earnest labor, higher aims. Every step towards higher, better, brighter life gives him reason for greater humility, larger faith, and stronger sense of the infinitude of duty and opportunity.

The work of the man of science is present still, and is never-ending. But, glancing at the past, he sees that he has no reason for discouragement, every reason for enthusiastic ambition. He sees a wonderful, a glorious, a fruitful work just begun, and his the privilege of taking part in it. His work is the basis of present highest human existence, the potential foundation of still nobler life. Great problems have been solved; greater and grander remain, which shall certainly be solved by him. His is the task of showing the way to make all the powers of nature genii aiding man; of giving comforts of every kind to his fellow, and powers of accomplishment of great work for public good; pointing out the way to give widely distributed enjoyment of life, leisure for moral development, for intellectual growth, opportunity for study of the universes, the attainment of highest physical, intellectual, moral ideals. He will yet penetrate the secrets of the living machine, learn how to evade the law of Carnot, to produce and apply the energies of chemical combination to the generation of heat without light, light without heat, power without waste; to transform thermal from chemical energy, without combustion at high temperature, as does the meanest animal; to convert it into mechanical power without the thermodynamic loss inherent in our heat engines, as does beast, bird, and worm; to obtain its equivalent of electric energy, as does the nervous system of every living creature; to intelligently select and sort out the radiant energies into luminous, thermal, or other etheric forms, at his will, as does the unconscious bit of hardly living jelly floating in the spume of the wave crest of every tropical sea.

XVI.

Our anticipations for scientific research, and for the future of its noble band of men of genius, may confidently be affirmed to be justified, however sanguine, by the history of the past and by the reasonable prophecy, in the light of the past, of its greatest seers. It may well be doubted if any living soul can realize, in full, the tremendous portent of that prophecy, and it is likely that its fulfillment will transcend the most ambitious and vigorous imaginings of our day. As the advances of the nineteenth century have inconceivably transcended the most enthusiastic prediction of the eighteenth, the revelations of the twentieth century may be expected to still further exceed the anticipations of the most far-seeing and sanguine prophets among men of science of our own time.

Genius and learning may be expected to persist in the coming times and courage is never lacking. The later Newtons will exhibit as great prescience as the earlier, the coming Davys and Faradays will accumulate no less learning than the great minds of the past, and the nerve of Heilprin, standing amidst lightnings, fire and smoke, and falling rains, mud, and lava, studying the processes of volcanic action from the edge of the roaring crater of Mt. Pelée, is as characteristic of the modern scientific investigator as was that of a Pliny, in a similar adventure, two thousand years earlier. 'With intelligence to guard his life against every needless risk, and yet with constancy and professional zeal to make him face cheerfully all inevitable danger,' such a man will always illustrate the 'un-

conscious courage and heroism of the scientific spirit.'* The true scientific spirit, however, is quite as often and as impressively shown by the investigator who publishes conclusions at variance with the beliefs of the world or of his own colleagues, and the physical suffering of a Galileo and the moral crucifixion of the promoters of almost every new discovery or new philosophy afford illustrations of this fact. But courage best appears in toleration.

The past, the present and the future have their special interests to the student of the trend of human progress, and it is easy, in a general way, to follow the line of the curve. Compare what is known of the older civilizations with the present of our own and the promise of the future for coming generations of civilized men!

In the days of the prehistoric races, whose only records are now found in the few relics here and there discovered by the geologist and the antiquarian, centuries passed without important changes, and progress was inconceivably slow as measured by the movement of the later days. Progress in the most enlightened countries was comparable to that of China during recent centuries and the barbarian stood absolutely still and remains, even to-day, as with his ancestors and forefathers of a thousand generations before science or civilization had a home or a name. The 'curve of progress' was practically rectilinear and horizontal through centuries and millenniums.

With the appearance of manufactures, trade and widening commerce and exchange, a rise became observable and the trend of progress during the periods of the history of the East Indian, the Babylonian, the Assyrian, and the old Greek was slowly but steadily upward. The discoveries and philosophies of Aristotle and his contemporaries and successors, the introduction of the Aristotelian methods of study of nature and of the sciences generally, the inventions of Hero and the other Alexandrians, of the mechanicians of the Museum and the Serapion, the revelations of the Ptolemys and the Euclids, the alchemists and the naturalists of the Egyptian period and of Greek mastery of the Nile: these events and these inventors in science, philosophy and mechanics produced the first observable acceleration and upward curvature. The Saracens, driving out the Greeks, substituting their own for the older civilization, but yet seizing and carrying forward the torch of knowledge and preserving every spark of the older light, promoting all the sciences, cherishing, learning all and caring for men of science, brought about a still more marked acceleration, and the upward trend of the curve continually became more observable until, by transfer into Italy, and in the hands of Leonardo, by importation into Spain through Moorish enterprise and wisdom, learning and the modern arts, so far as then known, all the sciences found safe and permanent home in Europe, despite the later opposition and persecution of the pioneers in science by the all too human elements of the dominant church.

But it was not until about the beginning of the seventeenth century, at a time when all the arts and all the sciences took a sudden start upward like the flowers of spring, that any rapid progress commenced. Then astronomy and physics and chemistry and all the applied sciences began to contribute to the advancement of learning, and Bacon's aspiration and Milton's cheerful leading, gradually bringing about a systematization of knowledge and a scientific method of advancement of science, began to illustrate the wonderful power of systematic work in well determined courses in accelerating all human progress. From the introduction of the inventions which gave firm foundation to the iron and steel manu-

* *The Nation*, June 5, 1902, p. 437.

facture, supplied the world with a reliable, powerful and cheap prime mover, made the factory system practicable and modern systems of manufacture feasible, the curve of progress has been rapidly, and more and more rapidly, mounting upward. Its coordinates may, from that date, be accurately measured and its locus precisely followed by collating the statistics of iron or the textile or the educational progress of the world's leading nations. They all follow a similar course and one is a gauge quite as much as another. The output of our colleges and especially of our colleges of engineering now follows the trend of progress of the nation and the output of men learned in applied science and that of our blast furnaces alike afford us a measure and a gauge of the advancement of the nation toward a still higher civilization.

A study of the curve of progress to date, and especially of the trend of progress at date, thus shows that we may find, in this revelation the rise and the advance of civilization into our own times, evidence which is convincing to the extent of proof that we are entered upon a stage in which the characteristic features are intelligent and systematic development of every department of human knowledge and of human skill, a stage in which scientific investigation is assuming constantly a more and more controlling share in the perfection of the sciences, the applied sciences and the arts of life. It is becoming constantly more and more productive of results favoring the progress of the race in its every department of life and growth.

Organized investigation of the problems of the industries is thus becoming as obviously useful and as generally employed in those fields as in pure science itself. 'The scientific method of science-advancement' is the method of every worker in every direction. The universities give large attention to research; it is cultivated by the colleges; it is the object of professional and industrial associations and of great endowed institutions founded for this special purpose.

The beginning of the twentieth century will probably become marked in history as that also of the organized industry of investigation, in all the departments of nature, of industry and of life, as that of the commencement of a rapid rate of acceleration of fruitful production, and as that of the firm establishment of science and of the scientific method as recognized elements of human progress.

In the promotion of this movement, no influence should be more potent and more general than that of Sigma Xi. This organization of the most brilliant minds devoted to science for science's sake—minds selected with care from among the choicest intellects coming forth from all schools, educated, learned, enthusiastic and capable, trained and expert—must, if it is maintained at its original and its present high standard, prove a mighty force for good in every field of most intelligent human activity, of highest scientific achievement.

Charles Sumner once said: "This is our talisman: Give us Peace! And population will increase above all experience, resources of all kinds will embellish the land with immortal beauty; the name of the Republic will be exalted until every neighbor, yielding to irresistible attraction, seeks new life in becoming part of the great whole and the national example will be more puissant than army or navy for the conquest of the world."*

"Give us Peace!" And science, art, industry and ability, conspiring, shall insure growth of population in numbers, wealth, comfort and intelligence and the revelation of nature's secrets, the utilization of na-

* 'Prophetic Voices concerning America,' Lee and Shepard, 1874.

ture's energies; and the inventions of a new century shall justify every one of Charles Sumner's 'prophetic voices,' from those of Seneca to those of Cobden, De Tocqueville and that orator, seer and prophet, Sumner himself. Seneca's continent has appeared and there are no more geographical worlds to conquer; but there are greater worlds still accessible to the scientific explorer. The prophecy of the 'bought servant,' George Webb, became true with the birth of a new nation:

Rome shall lament her ancient fame declined
And Philadelphia be the Athens of mankind.

Meantime, the nation, as prophesied by Sheridan, shall thus maintain a 'name and government rising above the nations of Europe with a simple but commanding dignity that wins at once the respect, the confidence and the affection of the world.'

And, in all this, the man of science, seer, revealer and prophet, shall play the noblest part.

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CORNELL UNIVERSITY.

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*ATTENUATION AND DISTORTION ON LONG-DISTANCE TELEPHONE AND POWER TRANSMISSION LINES REGARDED AS HYDRODYNAMIC PHENOMENA.**

THE analogy between a steady flow of water in a long pipe under the action of the constant head and a continuous current of electricity under some constant pressure such as is furnished by one or more cells of a battery, has often been employed to give a clear elementary physical conception of the mathematical relations expressed by Ohm's law. In this case the applied pressure is gradually consumed by the resistance experienced by the current, and in strict analogy with the flow of water, the loss per unit of length is proportional to the product of the square of the current and the first power of the resistance. So far as the mathematical relations are concerned the two problems are identical.

It is the object of this paper to extend this hydrodynamic analogy to the more complicated case of long-distance transmission by alternating currents in general.

Telephone transmission has been specifically mentioned in the title in order to include the general case of variable frequency. The importance of thus extending and enlarging this analogy will be evident when we reflect that all the complicated phenomena of long-distance electrical power transmission, by any combination of land lines and cables with their sending and receiving apparatus, may be completely reproduced in all its details of operation by simple pumping machinery with its transmission pipes and air chambers, whose manner of operation may be made clear to any one without the aid of higher analysis. Let us first take the case of a double-acting pump cylinder and piston in which the two ends of the cylinder are connected by a simple pipe or by-pass without valves. When this apparatus is filled with water and the piston is moved back and forth by a uniformly rotating crank, the water is forced through the by-pass alternately from one end of the cylinder to the other. If the by-pass is short, the resistance to motion may be taken as due to fluid friction only, since the inertia of the water may then be disregarded. This is in every particular analogous in the manner of its operation to a sinusoidal electromotive force acting in a circuit whose induction and capacity may be disregarded in comparison with its ohmic resistance.

But in case the pipe connecting the ends of the pump cylinder be made very long and the size sufficient to greatly reduce the friction, we may disregard this in com-

* Abstract of paper read before the American Association for the Advancement of Science by Professor Henry T. Eddy, University of Minnesota, Pittsburgh meeting, June, 1902.

parison with the resistance due to the inertia of the water. The resistance due to inertia is proportional to the product of the mass of the water moved by its acceleration. Since this acceleration is greatest at the beginning of the stroke and vanishes at the middle of the stroke, where it changes to a retardation of amount increasing to the end of the stroke, it is evident that the phase of the current lags a quarter of a revolution or period behind that of the pressure, the pressure being a maximum at the beginning of the stroke, and the current a maximum at the middle of the stroke. During the retardation of the piston the inertia of the water acts to drive the piston forward, and (disregarding friction) as much energy is returned to the piston during retardation as is exerted by it during acceleration, so that on the whole no loss of energy occurs during the stroke. In these particulars this case differs from that previously considered, where the pressure is in phase with the current and energy is expended against resistance during the entire stroke.

Now suppose that fluid friction and inertia coexist in the connecting pipe; it is evident that their coexistence does not affect the separate actions which have been described. The current or flow back and forth is that due to the reciprocating motion of the piston, and the pressure is the resultant of the two pressures already described, differing in phase by a quarter of a period. The lag of the current will, therefore, be less than a quarter of a period.

The inertia of the water is entirely analogous to the self-induction of an electric circuit and the case of combined fluid friction and inertia is mathematically in every particular the same as an alternating current circuit having distributed ohmic resistance and self induction.

Next let us imagine the short by-pass first considered to be sufficiently increased in diameter to make it a globular chamber as large or larger than the cylinder itself, and let it be furnished with an elastic diametral diaphragm (of sheet rubber, for example) which occupies a diametral position whenever the piston is at the middle of the stroke. It is evident that when the piston is at the beginning of the stroke the tension of the stretched diaphragm exerts a negative pressure or suction to force the piston forward in its stroke, which vanishes at the middle of the stroke, after which the pressure exerts a retardation whose amount increases to a maximum at the end of the stroke. But the total energy exerted by the diaphragm and restored to it is equal.

The action of the diaphragm differs from the action of the inertia of the water previously considered in the one particular only: it exerts its greatest forward pressure at the instant the inertia exerts its greatest back pressure, consequently when we disregard fluid friction, the phase of the current is one quarter of a period in advance of the pressure.

It thus appears that the effect of such a diaphragm is opposite to that of the inertia of the water, so that a diaphragm having sufficient tension would completely destroy the effect of the inertia of the water. The general effect of this arrangement is to relieve to a greater or less extent the greater pressures, positive or negative, at each end of the stroke arising from the inertia of the water. Furthermore it may be noticed that a somewhat different device from that just mentioned might be employed, whose resultant action would nevertheless be of the same nature. For example, instead of enlarging the by-pass let two equal air chambers be placed on it, one at each end of the cylinder. This is, in fact, the manner in which relief is actually obtained in pumping machinery, from the shock and greatly increased pressure at the beginning

and end of the stroke arising from the inertia of the water. Mathematically the effect is the same as that of the diaphragm previously described.

The operation of the diaphragm and air chambers just considered is strictly analogous to that of capacity in an alternating-current circuit, the diaphragm to capacity in series, and the two air chambers to capacity in shunt, and by these self induction may be neutralized to a greater or less extent, according to their relative amounts.

We have thus far considered merely the peculiarities of the transmitting or connecting pipes in their relation to the double-acting force pump regarded as the source of energy. We need next to consider a receiving pump which shall take and utilize the energy not expended in fluid friction. Let the receiving pump be assumed at first to be exactly like the force pump, and to actuate a crank, fly wheel and other machinery on which energy is expended uniformly. The crank end of this second cylinder is connected directly by a pipe with the crank end of the force pump, and the other ends likewise. In this case the energy expended in fluid friction and inertia may be neglected in comparison with the energy transmitted; this arrangement will transmit power from the driving crank to the driven crank much as would a belt or train of cog wheels. But suppose now that the second cylinder is connected to the first by very long pipes, miles long, for example, in which the inertia of the water becomes a controlling factor of the transmission. It would evidently become practically impossible to make the water oscillate with any rapidity in such a closed pipe under ordinary circumstances. But let there be a series of air chambers uniformly distributed along the entire length of the connecting pipes, or, what would amount to nearly the same thing, let the pipe be an elastic hose requiring pressure to enlarge or diminish its cross section.

This will at once entirely change the circumstances of the case, for the air chambers near the force pump will readily receive the water as it flows from the force pump and transmit it to those next along the line and so on, so that a wave of pressure will pass along the pipe and at the same velocity a wave of current will pass having its maximum flow at points where certain high pressure air chambers are discharging into those next along the line. By these progressive pressure and current waves, energy will be transmitted to the working cylinder which need not in this case be of the same cubic capacity as the force pump. Several complete waves may be in progress of transmission along the pipe at once. The frequency of oscillation in the working cylinder will be equal to that of the force pump, a number which may be computed in any given case. But the waves will lag in phase behind those of the force pump to an amount due to the number of waves and fractions thereof in progress of transmission along the line, and to the inertia of the working piston, etc.

It is evident that when the two cylinders are equal in every respect, except that the piston of the second cylinder is of such large mass that its inertia is great and when in addition we may disregard fluid friction, and the fly wheel of the second cylinder is running idle, that no work is expended in the system. In this case the second piston will originate transmission waves precisely as does the first but in opposite direction. The resultant of these equal and opposite progressive waves will be a system of stationary waves along the line. Whenever the amount of energy used at the working cylinder is small compared with the total energy, kinetic and potential, at and near the receiving apparatus the waves originating there will approach

the magnitude of those received by it. Any discontinuity of mass in the current flowing in the pipe, as for example, mercury in place of water for some part of the length of the pipe, will originate reflected or return waves. To insure good transmission, little or no discontinuity in the distribution of the inertia along the pipe should occur at any point such as would be due to changes of size or otherwise.

All these results are equally true of alternating-current circuits.

It may be shown from elementary considerations that the progressive velocity of the waves in the transmission pipe under consideration is constant for all frequencies of oscillation in case of a pipe in which the friction may be disregarded, but that the velocity increases as the square root of the frequency in any case where the inertia of the current may be disregarded. The case of the unequal velocity of the waves propagating the harmonic components of sounds in telephonic transmission by reason of their difference of pitch, which is one cause of the distortion of sound in long-distance telephone transmission, has been treated at length in the researches of Dr. Pupin who has investigated very fully the inductive (or inertia) loading necessary to render lines practically distortionless. This is equally a hydrodynamic phenomenon.

The one question remaining for elucidation is that of the attenuation or gradual diminution of amplitude of waves as they progress along the line.

It may be readily shown that in both of the two extreme cases already considered, viz., those in which either friction or inertia is disregarded, that the logarithm of the reciprocal of the amplitude, or intensity of the wave at any point, varies directly as the product of the distance of the point from the source of the wave by its velocity. Since this velocity has already been shown to be constant in case the fluid friction may be disregarded and to increase with the frequency in case the inertia is disregarded, it is evident that attenuation depends upon frequency in case of fluid friction without inertia, but it is independent of frequency in case of inertia without fluid friction. Such unequal attenuation in the telephone obliterates to a greater or less extent tones of high pitch before it does those of lower pitch. It is therefore necessary to distinct transmission that the self induction of the line should be large enough to store a large amount of kinetic and potential energy in the wave motion along the line, which in all its aspects is strictly analogous to the wave motion propagated in the water in the apparatus just described.

THE CARNEGIE INSTITUTION.

The officers of the Carnegie Institution have appointed advisory committees and have invited suggestions from men of science. The executive committee has therefore under consideration a large number of reports and recommendations, but as these must in large measure be regarded as confidential, it is probable that the committee would welcome a public discussion of the entire question of the endowment of scientific research. Science appears to be the best place for such discussion; and it would doubtless be for the common good if those who are interested in the subject would make known their views before the meeting of the trustees in November. At that time a definite policy may be adopted, which cannot thereafter be altered. There are so many diverse possibilities and conflicting interests that these can only be sifted and reconciled by full and free discussion.

It appears that the Carnegie Institution can either undertake certain large plans for the promotion of science or can assist a great number of special researches,

and it is probable that both methods will be adopted. The trustees will doubtless follow the principle laid down for the Smithsonian Institution by Henry and will not undertake anything that can be done equally well by other agencies. They will cooperate with existing institutions and promote new and independent centers of research, rather than establish any institution that might rival those already in existence, or undertake the control of the agencies that they may assist. Thus the Smithsonian Institution performed a service of immense value in inaugurating investigations in meteorology and fish culture and then letting these develop into the Weather Bureau and the Fish Commission. It has done work of equal importance in fostering the National Museum, the Bureau of American Ethnology and the Zoological Park, but in my opinion the time has now come when these institutions should be released from their leading strings.

It appears to me that neither of the two plans which I have heard especially discussed for the Carnegie Institution is advisable—namely, the erection of a geophysical laboratory at Washington and the acquirement of the Marine Biological Laboratory at Woods Hole. I should suppose that a geophysical laboratory at Washington would do work that might be undertaken by the Coast and Geodetic Survey and the Geological Survey, and would prevent the government from doing such work. It would seem to be better for the Carnegie Institution to employ a commission to outline the geophysical researches most needed, and then to promote them by providing equipment and making it possible for those most competent to undertake the work, always looking forward to the time when it can be handed over to the government. Even the great income of the institution, if divided among the sciences, is limited when compared with the $1,000,000 appropriated by the government for the Geological Survey.

The acquirement of the Marine Biological Laboratory at Woods Hole is, it seems, being seriously considered by the executive committee of the institution, and this plan may therefore with advantage be discussed in some detail. It appears that the corporation has voted to transfer the laboratory to the Carnegie Institution. It was stated at the meeting of the corporation that the executive committee would recommend to the trustees the acceptance of the laboratory, the erection of buildings and an annual allowance of $20,000. It was the preference of nearly all the members of the corporation that the laboratory should be assisted by the Carnegie Institution without being made a branch of it; but the alternative was placed before them of giving away the laboratory or losing the large support of the Carnegie Institution and perhaps witnessing the establishment of a rival laboratory.

Now the Woods Hole laboratory has been dear to many biologists of the country exactly on account of its independent position and democratic organization. It is the only institution of national importance that is controlled by scientific men. There is a corporation composed chiefly of those who have carried on research in the laboratory, and this corporation elects trustees who represent different universities. The results have been what might have been anticipated from this democratic organization; there have, on the one hand, been financial troubles, and, on the other hand, there have been great enthusiasm, loyal devotion and much self-sacrifice. It seems that this is a case where the Carnegie Institution might relieve the financial difficulties without suppressing the public spirit and service of those who now conduct the laboratory. If the institution should offer

to contribute for the present $10,000 a year, on condition that those interested in the laboratory contribute an equal sum, the condition would be met, and the funds of the institution would go twice as far as if it assumed control. They would indeed go further; for example, the director and other scientific men serve the laboratory without salary; should a director be appointed from Washington, he would naturally expect and should receive a salary of $5,000 or $10,000. If the laboratory is continued as an independent institution, it will sooner or later receive adequate endowments, and the Carnegie Institution can then use its funds for other purposes. If the laboratory is made equal to the station at Naples, and nothing less has always been intended by those interested in it, an annual appropriation of $50,000 will be required; should branches be established and an experimental farm added, this appropriation will need to be doubled, and no money would remain for purposes equally important for the advancement of biology. It seems that as a branch of the Carnegie Institution the laboratory would either be less adequately supported than if it had remained an independent institution, or it would be aggrandized at the cost of other biological laboratories, exploring expeditions, etc. In either case the centralized power of money would crush the only serious attempt of scientific men to conduct an institution for research.

The fact that the erection of a geophysical laboratory at Washington or the acquirement of the Marine Biological laboratory at Woods Hole does not seem to be the best use of the endowment of the Carnegie Institution, does not mean that the institution should not conduct any laboratory. There are undoubtedly serious difficulties in the way of simply distributing the entire income among existing institutions. These institutions might depend on subsidies rather than on their own efforts, and they might transfer to other uses funds that are now spent on the objects that the Carnegie Institution would support. It is reported that one small college has asked that its share of the fund be forwarded. As a matter of fact there are not urgent and important demands on the funds for research already existing—the Elizabeth Thompson Science Fund, the trust funds of the National Academy of Sciences and of the Smithsonian Institution, and the research fund of the American Association for the Advancement of Science.

The Carnegie Institution can not with advantage be an Elizabeth Thompson Science Fund on a large scale; neither should it abandon its individuality to merge its income in existing agencies. The national government spends $10,000,000 a year on its scientific departments, and universities spend annually in their various activities a much greater sum. The income of the Carnegie Institution, if merged with other agencies or made coordinate with them, would simply add 1 or 2 per cent. to the scientific activity of the country, which is already increasing at the rate of perhaps 10 per cent. each year.

The endowment of the Carnegie Institution if invested in government bonds would yield an income of $200,000; if invested in securities approved by the courts for trust funds, from $300,000 to $350,000. Perhaps one fifth of the income will be required for the expenses of administration. It may be that Mr. Carnegie will enlarge the fund; this will doubtless depend on his judgment as to whether or not the money is used more effectively for the public good than it could be in any other way. It seems that for the present at least one half of the income might be used to best advantage in assisting researches and existing institutions throughout the country, and in establishing new agencies that would become

independent. The other half might be used for the establishment of an institution at Washington that would promote scientific research in a way that would not interfere with existing agencies, but would rather set them a standard.

I should like to see at Washington a Carnegie Institution somewhat on the plan of the Royal Institution of London, which, as we all know, was founded by an American. Such an institution might be made the center for the scientific life and activity of the country. The government should provide the site for the building as part of the plans for the improvement of Washington, and half the income of the institution for the next three or four years could be spent for its erection. It should contain rooms for the meetings of national and local societies, for boards and committees, and for lectures. It should contain comparatively small but admirably equipped laboratories for the three fundamental sciences—physics, chemistry and psychology.* There should be a professor or director for each of these sciences with a salary of $10,000, whose duties it would be to conduct and direct research work in the laboratory, to coordinate and promote the research work of the country and to give a few lectures. He should have suitable assistants, computers and instrument makers at a cost perhaps of $10,000, and about $5,000 annually should be allowed for apparatus, with occasional special grants if needed. Efficient investigators, perhaps not more than five or six in each science, should be encouraged to carry on research in the laboratories for a year or less; these men should have leave of absence from their own institutions and would in most cases receive subsidies from the general funds of the Carnegie Institution. They should give short courses of public lectures, and other men of science should be invited to present the results of their researches in lectures or articles. These should be well paid for and should not be published exclusively by the institution, but distributed freely to newspapers and journals. Then there should be a board of managers, representing each science or important branch of a science. In the exact and natural sciences there might be perhaps twenty of these managers, who would include the directors of the laboratories. With the president and secretary they should be given full and complete control of the scientific work of the institution, subject only to the veto of the board of trustees. Membership in this board of managers should be the chief distinction in American science, being conferred on those who unite eminence in research with public spirit and executive ability. The members should receive a salary of say $2,500 a year; they should meet together at Washington for a week once a year, and perhaps should be present on one other occasion as chairmen of honorary committees on each science. Each should present a lecture or paper annually before the institution, perhaps reviewing the progress in the United States of the science that he represents. On the plan outlined the annual charge for the laboratories would be $75,000 and for the board of managers, $50,000. The expenses of the central institution would thus be $125,000, to which must of course be added the cost of administration. I see no other way by which an equal sum could so effectively contribute to the advancement of science. A considerable amount of research of the highest class would proceed directly from the institution and would become quickly and widely known. The directors of the laboratories would in the character of their

* In ranking psychology with physics and chemistry I may be influenced by the direction of my own work. I believe, however, that I am logically correct. The fact that psychology is at present more immature than physics or chemistry appears to be a reason for giving it opportunity.

work and in their salaries set a standard that universities and other institutions would endeavor to meet. These positions and membership in the board of managers would be a recognition of eminence and efficiency in scientific work; they would encourage men of science and make scientific work a more attractive career to young men of promise.

In connection with the central institution the question of publication should be considered. It seems to me that it would be far better to coordinate and assist existing series and journals rather than to establish new ones controlled by the institution. The present difficulties in the publication of scientific research are certainly lamentable. The proceedings of learned societies, in which subjects of all sorts are treated in a single volume, are a survival from the eighteenth century. The cost of printing, engraving and distribution, as compared with the conditions abroad, is a serious drawback to science in America. A series of monographs published by the Carnegie Institution might be of use, but would take from rather than contribute to the activity of other institutions. The publications of the Geological Survey cost $300,000 annually, and the funds of the Carnegie Institution would go but a small way in this direction. Much more, it seems to me, would be accomplished by establishing in Washington as part of the central institution a press which would employ competent draughtsmen, engravers and proof-readers and would offer its services at such charges as are made in Germany and France. The academies of the country might then unite in publishing their proceedings in series devoted to the several sciences, and our various scientific journals could secure publication on terms as favorable as those of foreign nations. The autonomy of existing publications and their support would thus be maintained, while the fact that they came from the press of the Carnegie Institution would at a comparatively small cost contribute greatly to the prestige of the institution.

If one half the income of the institution were expended as indicated, a considerable sum would remain with which the trustees or board of managers could play the part of a special providence throughout the country. This would allow annually one or two large appropriations and a great number of smaller subsidies. It seems that the institution might in some cases with advantage give endowments rather than money for current uses. Such endowments would certainly tend to make widely and permanently known the beneficent work of the institution. The erection of a laboratory at Woods Hole, costing $100,000 and called the Carnegie Biological Laboratory, or an endowment fund of equal amount, to be known as the Carnegie Research Fund for Biology, would in my opinion be of more value to the laboratory and to the cause of science in America than any annual subsidy. One large grant each year or two, or two or three smaller ones, either establishing permanent agencies or carrying forward projects of some magnitude, would perform an inestimable service and would stimulate and not inhibit similar gifts from other sources. Supposing the turn of psychology to come once in ten years, I can easily outline work for a century—for example, a station for the study of living animals in connection with a zoological park; a laboratory for the study of children as part of a foundling or orphan asylum; another in connection with asylums for the blind and deaf; a clinic for the psychological study of the insane; another for diseases of the nervous system and organs of sense; an expedition to collect psychological data regarding savages before they disappear; a shop where psychological instruments can be made and instrument-

makers trained; a bureau for statistics and computations. These and other agencies would add greatly to the efficiency of existing laboratories of psychology and would in no wise conflict with them. Each could be established with a fund of from $50,000 to $100,000, and if made independent it would continually grow in resources and usefulness. There are doubtless in other sciences objects equally deserving and urgent, so that if the endowment of the Carnegie Institution were doubled or quadrupled the income could be used economically and advantageously.

If one half the income were expended on the central institution at Washington and one fourth on large objects, there would remain $75,000 to $125,000 for smaller grants and special researches. This sum could easily be spent to great advantage without interfering with other agencies.

There are certain international undertakings in which the United States should share and for which no money is available. We may hope that the general government will ultimately recognize its obligations in this direction, but for the present our national self-respect and usefulness are impaired because we can not join on equal terms with other nations. Thus we were unable to send delegates to the third conference on an international catalogue of scientific literature, with unfortunate results, as some of the measures adopted by the first and second conferences on the recommendation of our delegates were reconsidered by the third conference.* We have now no adequate means to do our share in seeing that the publications of the United States are adequately included in the international catalogue, whereas most foreign nations have made appropriations for this purpose. In like manner we are unable to assist in the work of the Concilium Bibliographicum conducted at Zurich as an international undertaking by an American. Funds for sending delegates to the International Association of Academies were secured with much difficulty; and in general delegates to such international conferences and congresses must pay their own expenses. There are various international institutions, and more are continually being established, toward which the United States should contribute its share. In these directions the Carnegie Institution can perform large services at comparatively small expense.

There are also certain national or more local institutions which might be assisted without interfering with their autonomy, and in such a way that the aid would encourage rather than discourage other resources. The laboratory at Woods Hole appears to be the best type of these; there are numerous other marine and fresh-water stations, similar in character if less national in scope. The Blue Hill Meteorological Observatory or the Dudley Astronomical Observatory may be mentioned as examples of institutions that are doing excellent work with small resources. Should the Carnegie Institution make an appropriation on condition that it be duplicated locally, its funds would be spent to advantage.

It would be perhaps more difficult to assist directly the work undertaken by the national government, the states and municipalities, or by our richly endowed universities, observatories, museums, etc. If the funds were unlimited a laboratory of physical chemistry given to Harvard or Cornell, a needed collection given to the National Museum and the like, would certainly contribute to scientific advance; but such gifts would not be the most economical use of a limited income. There are, however, cir-

* To give a case in which I am interested, psychology' was included in the catalogue at the recommendation of Dr. Billings, but was made a branch of physiology at the third conference, when no psychologist or American delegate was present.

cumstances where cooperation with other great agencies for scientific investigation might be most fertile in results. Thus, if at present the Carnegie Institution would offer to equip an antarctic expedition to cooperate with those of Great Britain and Germany, on condition that the government furnish ships and officers, the offer might be accepted. Or to take a modest case within my immediate experience—we need urgently in the psychological laboratory of Columbia University a computer who could also act as a trained subject for psychological measurements. Such computers and aids are as much needed in psychology as in astronomy, but they do not at present exist, and it is difficult to persuade the trustees of a university that this is really a pressing demand. Should the Carnegie Institution offer to give $500 a year for three years toward the salary of a computer on condition that Columbia University contribute an equal sum, it would doubtless do so. After three years the support of the computer would probably be assumed by the university, and similar offices would be established in other universities here and abroad. In a case such as this a very small sum would contribute greatly to the advance of psychology as an experimental science. This case is given simply as an example of the way in which the Carnegie Institution could accomplish results by cooperating with existing institutions.

Two of the most important agencies for the advancement of science are societies and journals. Whatever can be done to promote their efficiency will contribute greatly to scientific progress. In many cases grants made to scientific societies might be administered more effectively than if the Carnegie Institution undertook the direct control. Thus the American Association for the Advancement of Science, with an endowment fund of about $10,000, is able to appropriate annually about $300 for research. This insignificant sum is divided among five or six committees who supervise work of importance. If the resources of the association were increased, they might under the auspices of its committees be expended more economically than direct grants from the institution. Or, to take again an example from my own science, the American Psychological Association has gradually acquired from the dues of members a fund of about $1,000. The proposal has been made that this money be used for a psychological bibliography, which does not at present exist and is urgently needed. It is estimated that such a bibliography will cost $2,000, and it will be necessary to wait some years before this sum will accumulate from the dues of members. Should the Carnegie Institution add $1,000 to the equal sum in the possession of the association, it would be possible to proceed with the bibliography. The money would be spent economically, as only clerical work and printing would be paid for, while the skilled labor would be given by the association.

The great area of this country interposes a serious obstacle to scientific organization. If means could be found for paying the railway expenses of delegates to the meetings of our national scientific societies, a forward step of great importance would be taken. I scarcely see how the Carnegie Institution could undertake this large project, but it might cooperate with societies and educational institutions in forwarding it.

In the case of scientific journals I can speak with some experience. Our scientific journals are absolutely essential to the progress of science. Those devoted to pure science are in all cases scientific and educational institutions, not commercial enterprises; most of them are in need of support and deserve it as much as universities or museums. It is, however, difficult to give such support in a useful and economic-

al way. Thus to illustrate from the journals that I edit—SCIENCE when liberally subsidized by Mr. Bell and Mr. Hubbard was conducted at an annual loss of $20,000; *The Popular Science Monthly,* established in part as a commercial enterprise and fairly successful as such when the doctrine of evolution was treated as a religious rather than as a scientific question, was latterly conducted by the publishers at an annual loss of $10,000 and finally relinquished by them; *The Psychological Review* has always been published at a loss, which would be large if money were at hand to lose. I give these illustrations to indicate that if the Carnegie Institution undertook to own or control our scientific journals, the expense would be very great; whereas I believe that there would be no appreciable improvement in their contents, but, in the end, injury to the cause of science. It seems that in connection with the plan for the acquirement of the Woods Hole laboratory, the officers of the Carnegie Institution have asked for an option on the *American Journal of Morphology.* I trust that the institution will not undertake to own and control a journal of this character, and that those at present responsible for this journal will not abandon it. Our scientific journals should be controlled by the scientific men of the country, preferably in connection with their societies.

The fact that the Carnegie Institution should not assume control of scientific journals does not mean that it should not assist them. It will as a matter of fact do so indirectly by every action that increases the quantity or improves the quality of scientific research. I have already mentioned the great gain that would accrue if an office for printing and engraving were established that would permit the manufacture of scientific journals and books on terms of equality with foreign nations. Without direct subsidies the institution could assist in the support of scientific journals by advertising in them those of its activities that should be made public, and by subscribing for copies to be sent to the smaller libraries and institutions of learning.

In addition to such special agencies as it may establish and to cooperation with institutions, societies and journals, the Carnegie Institution can assist directly individuals and their researches. Mr. Carnegie has specified as one of the main objects of his foundation, "To discover the exceptional man in every department of study whenever and wherever found, inside or outside of schools, and enable him to make the work for which he seems specially designed his life work." This as a matter of fact should be the chief function of society and has indeed been the course of nature since the beginning of organic life; but the time may now have come when we can do consciously and economically what has hitherto been done blindly and with boundless waste. It is evidently possible for the Carnegie Institution either to aid those who are beginning research or those who have already proved their ability; and it seems that both classes should be assisted in so far as the means of the institution permit.

Several university presidents have recently stated that our system of fellowships has been sufficiently extended; but in this I do not concur. It is certainly not true for my own science and my own institution. One fellowship in psychology is annually awarded at Columbia University, whereas ten could now be given with advantage, and the number needed would probably always increase in more rapid ratio than the number supplied. We can only find the exceptional man by selecting him from a considerable number who undertake research work. Those who prove themselves incompetent for important orig-

inal investigations have not wasted their time, but are better prepared for teaching or other kinds of work. To pass beyond the limits of the already known, to discover new truth and new methods by reliance on individual initiative and judgment, to do and give and not merely learn and receive, is an educational method incomparably better than any other. Those who have accomplished this either at the university or in active life are the world's leaders. The student is in no sense pauperized because he receives a fellowship. His research is worth on the average far more than it costs; he gives to the world more than he receives and earns his living by honest work.

If I may venture to suggest a definite plan for the award of fellowships, it would be that each university be permitted to nominate for a Carnegie fellowship, one of every ten of those on whom it confers the doctorate of philosophy. These men—who at present would number about fifteen in the sciences—would be well prepared for research and could carry it forward for a year to great advantage at Washington or elsewhere. The value of the fellowships should be $1,000.

The Carnegie Institution will doubtless also undertake to promote scientific research by enabling men to devote themselves to investigation who have already proved themselves competent, but who are prevented by various causes from doing the work for which they are fit. The greatest obstacle to the advancement of science is, in my opinion, the circumstance that scientific men are not directly rewarded for their investigations and discoveries. The lawyer, physician or engineer can command a fee commensurate with the value of his services, the artist can sell his picture for what it is worth, the novelist receives a royalty on as many copies of his book as the public will buy; but the man of science as a rule gives his research work to the public. He earns his living by teaching or otherwise, and is thus an amateur, not a professional investigator. In a few cases the patent office intervenes, and we see what it can accomplish, for example, in Mr. Edison's inventions. But the field covered by the patent office is small, and as a rule it is more likely to divert from than to encourage research in pure science. If some method could be devised by which society would pay the man of science even one tenth of the value of his investigations, science would enter a new era of progress. Possibly the Carnegie Institution may find some means to accomplish this end, for example, by paying an investigator for his research at the same rate that a magazine pays for a short story; but the problem is complicated and difficult. The offering of prizes is an obvious, but I fear not very satisfactory or effective, method.

I am sufficiently optimistic to believe that the combination of teaching or economic work with research is on the whole an advantage. The authorities of Columbia University expect me to give one undergraduate course with laboratory work and one advanced course with the supervision of research work. This amount of teaching, I think, improves the quality of the research work that I am able to do and does not seriously limit the quantity. Indeed the cooperation with students may increase the quantity. It would, however, doubtless be an advantage for men engaged in teaching or economic work to have occasionally a year free, devoted entirely to research, at Washington or abroad. Columbia University does not demand an excessive amount of teaching and allows a leave of absence one year in seven with half salary. Some other institutions are less fortunate or less wise, and the Carnegie Institution could accomplish results of immeasurable importance by permitting those engaged primarily in teaching or

economic work to devote a year to pure research. The results would extend far beyond the single year or the single individual. If the Carnegie Institution can arrange to pay half the salary of an investigator, giving him at the same time the best facilities for research at Washington, at one of our well-equipped universities or abroad, requiring the institution with which he is connected to pay the other half, its funds would be spent wisely and economically.

There are certain men of genius or talent who for one reason or another have not been able to find a place in our organized social machinery. Such men might perform work of value if given the opportunity, and the Carnegie Institution could here assist in a way that is not possible for any other institution.

The two general principles which I have kept in mind in writing the above are that the Carnegie Institution should do (1) what it only can do, working whenever possible with existing institutions; and (2) should aim to increase the influence of men of science, working with them and through them.

The executive committee and the trustees of the Carnegie Institution will have before them reports prepared by those most competent to give advice, and their final decisions will be better considered than the views of any individual. I have ventured to print these remarks, based chiefly on the science with which I am engaged and the institutions with which I am more or less familiar, on the supposition that suggestions from all quarters will be welcomed by the officers of the institution. I have of course expressed only my individual opinions and have in no wise attempted to represent the policy of the journal in which they happen to appear. As responsible editor of this journal, however, I urge men of science to join in a discussion of the problem as to how endowments for research, and especially the great endowment of the Carnegie Institution, can best be used for the advancement of science.

J. MCKEEN CATTELL.

COLUMBIA UNIVERSITY.

SCIENTIFIC BOOKS.

Lehrbuch der Combinatorik. Von DR. EUGEN NETTO. Leipzig. B. G. Teubner. 1901. Pp. viii + 260.

At the present time neither European nor American universities offer lecture courses on the subject of combinatorial analysis. This fact is the more noteworthy when we remember that during the first quarter of the nineteenth century nearly every mathematical chair in Germany was occupied by a specialist in that field. This Combinatorial School of Germany has passed into deserved oblivion. Under the leadership of C. F. Hindenburg it represents the culmination of an unfortunate tendency of eighteenth century mathematicians to develop analysis, particularly the subject of infinite series, with reference to form only, and to pay little or no attention to the actual contents of formulæ. The polynomial theorem was hailed as 'the most important theorem of all analysis.' In combinatorial analysis (combinatoric) the German school was contented with the deduction of rules for the writing down of all the combinations and permutations that are possible under given restrictions. The simple fact that the able and fairly complete treatise now under review hardly mentions the work of Hindenburg shows that what are now considered the substantial parts of combinatoric have been developed outside of the German Combinatorial School. Associated with the early development are the great names of Pascal, Leibnitz, Wallis, James Bernoulli and De Moivre.

While combinatoric is not now made the subject of lectures in our universities, it is nevertheless of importance. The student acquires much of it during the pursuit of other branches. It is touched upon in the study

of ordinary algebra, of determinants, of substitution and group theory, of the theory of numbers, and of the theory of probability. Netto's book is of value as a reference book, especially as no text of importance on combinatoric has been published for sixty-five years. In arrangement and selection of material it resembles somewhat Netto's brief article 'Kombinatorik' in the 'Encyklopädie der Mathematischen Wissenschaften.' The book takes notice of researches of recent date, including several papers by American authors. Starting out with the fundamental definitions the author treats of combinations, permutations, and variations under different limiting conditions, leading up to various problems, as, for instance, Tait's problem of knots. Combinations and variations are considered under the restriction of a definite sum or a definite product of the elements. The partition of numbers and Durfee's graphs are taken up. In the course of further combinatorial operations the author studies systems of triads arising in connection with Kirkmann's and Steiner's problems. Steiner's queries have not yet been fully answered. Kirkmann's is the 'Fifteen School Girl Problem': 'To walk out fifteen girls by threes, daily for a week, without ever having the same two together.' In the discussion of this it is to be regretted that Netto overlooked E. W. Davis's pretty 'geometric picture,' given in the *Annals of Mathematics*, Vol. XI., 1897, where a one-to-one correspondence is established between the fifteen girls and fifteen points on a cube; eight points at the corners, six at the mid-points of the faces, one at the cube-center; the thirty-five triads are then easily found.

Netto's book is substantial food for the average reader. Yet some topics in combinatoric were originally suggested by questions propounded for amusement. The 'problem of the eight queens' is of this nature. Eight queens are to be placed upon a chessboard so that none of them can capture any other. It was first propounded in Berlin in 1848 and has 92 solutions. J. Bernoulli, in his 'Ars Conjectandi' (1713), gives certain hexameter lines in which the words were to be changed about in every possible way, yet so that every new arrangement still conformed to the laws of verse. Thus the hexameter,

Tot tibi sunt dotes, Virgo, quot sidera cœlo,

studied by several pious mathematicians, admits, according to Bernoulli, of 3,312 such arrangements. An interesting recent book, taking up combinatorial and other mathematical topics for the purpose of recreation, is W. Ahrens' 'Mathematische Unterhaltungen und Spiele' (Teubner, 1901).

FLORIAN CAJORI.

COLORADO COLLEGE,
COLORADO SPRINGS.

DISCUSSION AND CORRESPONDENCE.

THE OPPORTUNITY FOR FURTHER STUDY OF VOLCANIC PHENOMENA.

TO THE EDITOR OF SCIENCE: It has been just four months to-day since the terrible calamity at St. Pierre occurred. Much has been written and said concerning it. Many able scientific men—French, British and American—have examined the locality and published thereon, but so far as I am aware their observations and conclusions only point to one deduction—that the terrible secret of Pelée's destructive clouds is still unsolved, and that the volcano still exhibits a deadly unexplained force, as attested by two thousand additional victims last week.

I think I may speak correctly, when I say that all the visiting geologists agree upon the major geological facts and only diverge seriously when they reach the field of speculation concerning the nature and behavior of the mysterious gases and clouds of lapilli, which descend instead of arising, which developed marvelous electric effects, after passing away from the crater, and which create powerful destructive forces.

So far as I am aware there was not a single member of the American scientific corps who did not leave the scene with a knowledge of the incompleteness of his studies and the lack of facilities for study during the brief time he was there. One of these, Professor Heilprin, has returned to the scene at his own expense, but, alas, even if he has survived

last week's eruption, he was not equipped with means to complete the work.

While more geological study is needed, the chief problem of Pelée is the nature of its gaseous ejecta, and it is no longer within the power of a geologist single-handed to solve it, but a carefully planned and equipped coöperative expedition accompanied by physical, chemical and photographic apparatus is needed.

In order to advance knowledge a party should be sent to Martinique for an indefinite stay of several months, with spectroscope, seismographs, chronographs, special photographic apparatus and all necessary equipment to study the eruptions with special reference to their electrical, magnetic, gaseous and other physical behavior. Furthermore, some society or individual should have seismographic stations established throughout the West Indies and our southern coastal plain—and this could be probably aided by our Coast and Geological Surveys, or by the Weather Bureau.

A temporary and healthful observatory and laboratory could be established on the slopes of Carbet overlooking Pelée, from which studies could be made with perfect safety. The talk about the danger of the annihilation of the island is all wrong. The recent deaths were all within the previous zone of danger coincident with the slopes of Montagne Pelée proper, but the rest of Martinique, except villages at sea level in reach of tidal waves, is perfectly secure.

Never was there a time so propitious or important for concerted effort to secure new and important light upon the behavior of volcanoes, and some society or individual should immediately raise the funds to conduct and direct this important work.

Americans are letting a great opportunity pass to add to knowledge, and I humbly beg that those who are in a position to equip such an expedition or to influence our learned societies or individuals, give this subject their serious consideration.

ROBT. T. HILL.
U. S. GEOLOGICAL SURVEY.

MR. BORCHGREVINK ON THE ERUPTION OF MT. PELÉE.

TO THE EDITOR OF SCIENCE: There are certain features of the article 'History's Greatest Disaster,' by C. E. Borchgrevink, descriptive of the eruption of Mt. Pelée, Martinique, in May of the present year, and published in the July number of *Frank Leslie's Monthly,* which are so inaccurate or misleading that they should be corrected.

On page iii of the 'Martinique Supplement' referred to there is an illustration with the caption: "This remarkable photograph was taken during the grand eruption [of Mt. Pelée] of May 20th. The camera was knocked from the photographer's hand and was not recovered till the following day. The fate of the photographer is unknown." The facts are that this photograph was not taken on May 20; it does not represent an eruption of Mt. Pelée; the photographer did not lose his camera; he is still doing business in Kingstown, St. Vincent. The photograph was taken by J. C. Wilson, photographer, of Kingstown, St. Vincent, and it represents an eruption of La Soufrière.

On page iv there is an illustration with the caption, 'The smoking lava beds of Pelée.' This illustration was not made from a photograph of any part of Mt. Pelée, but from a photograph of the mouth of the gorge of the Wallibou river, St. Vincent, with Richmond Peak (a part of Morne Garou) in the background.

On page xiii of this article on Martinique there is a picture labelled, 'The two craters of La Soufrière.' These so-called craters are not on Martinique. The illustration was made from a photograph of the Pitons of St. Lucia, which is a stock picture in all photographers' shops.

The last instance to be noted is one on page xvi, which is called 'General view of the island'—presumably of Martinique, since the article deals solely with that island. This illustration is not of Martinique. It is a composite, made up from two photographs of La Soufrière, St. Vincent, taken from nearly the same point of view. In the middle distance we have, be-

ginning at the left, Chateaubelair island, strait and point, and the same repeated. The island in the middle of this illustration is composed of Chateaubelair point on the left and Chateaubelair island on the right.*

There are some statements in the article which would not have been made by the author had he spent more time in the study of the volcanoes which he was sent by the National Geographic Society to investigate as a scientist.

It seems to the writer that Mr. Borchgrevink should explain such very inaccurate statements as those cited regarding four important illustrations accompanying his article. These corrections are particularly important at the present time, because Mr. Borchgrevink is now trying to raise funds for another expedition to the Antarctic regions and the public should be satisfied as to the scientific accuracy of one who desires to undertake such enterprises.

The writer feels qualified to make the preceding criticisms because he spent nearly seven weeks on Martinique and St. Vincent studying the phenomena of these eruptions.

EDMUND OTIS HOVEY.

AMERICAN MUSEUM OF NATURAL HISTORY.

* Compare this picture with the second one on page 790 of September *Century Magazine.*

PATAGONIAN GEOLOGY.

IN a recent publication,† F. Ameghino gives again a new table of the geological succession of the different Cretaceous and Tertiary beds found in Argentina. This scheme differs from those published by him previously in several respects, but, as in all his former publications, he fails to give any evidence whatever for the succession of the respective beds, and thus this new scheme has only the same negative value as all the previous ones.

Moreover, in some respects, the present scheme is entirely opposed to some of the observations made by J. B. Hatcher* in southern Patagonia, and the results obtained by the present writer in studying the Tertiary invertebrates collected by Hatcher.†

This discrepancy is most evident in Ameghino's conception of the so-called Patagonian formation, which is regarded by Hatcher and the present writer as a geological and paleontological unit of marine beds, while Ameghino divides it into no less than six marine horizons, which, in part, correspond to four continental horizons.

The general trend of our demonstration that Ameghino's divisions are untenable, is that the so-called characteristic fossils of the latter do not actually characterize them, but are found associated in the same layers.

It may be said that the fact that some of the characteristic fossils are found in more than one of Ameghino's horizons does not alter the general character of difference of the various faunas. But I wish to emphasize here that I have shown this not for *some* or *a few* of the 'characteristic' species, but for *practically all of them.* The few exceptions are formed by comparatively rare species which are altogether unfit to be used for the discrimination of horizons (see Ortmann, *l. c.,* p. 284).

But it is not only the lack of all evidence for his views that we have to complain of in Ameghino's paper, but it is the way in which he treats some of the deposits that have been closely investigated by us, by adding to and taking away from the evidence given by us.

I shall mention only the most striking instances.

The Cape Fairweather beds are placed by Ameghino, in his table, in the Lower Pliocene, between the Lower Tehuelche and the Ensenadense beds. He says of the fauna of these deposits that it contains 50 per cent. extinct mollusks, and gives the following characteristic fossils: *Ostrea ferrarisi, Chlamys (Pecten) actinodes, Turritella innotabilis, Trophon inornatus,* etc.

† Ameghino, F., 'Cuadro Sinóptico de las formaciones sedimentarias, Terciarias y Cretáceas de la Argentina an relacion con el desarrollo y descendenia de los Mamíferos,' *Anales del Mus. Nac. de Buenos Aires,* vol. 8, 1902, pp. 1–12.

* See *Amer. Jour. Sci.,* vol. 4, 1897, pp. 327–354, and *ibid.,* vol. 9, 1900, pp. 85–108.

† 'Rep. Princeton Univers. Exped. Patagonia,' vol. 4, part 2, 1902.

The facts concerning these beds, which were discovered by Hatcher, and the fauna of which was studied by Pilsbry (*Proc. Acad. Philad.*, 1897) and the present writer, are as follows (see Ortmann, *l. c.*, p. 307 f.):

The Cape Fairweather beds are supposed to be Pliocene. They lie uncomformably on top of the Santacruzian beds (Miocene according to Hatcher, Eocene according to Ameghino). This is all that is known of their stratigraphy. They contain a fauna of fourteen species, among which *Ostrea ferrarisi* is *not* found, and of which 57 per cent. are recent.* The most characteristic (and abundant) species are *Pecten actinodes,* of Ameghino's list; but, besides, several others *must* be mentioned, namely, *Terebratella gigantea,*† *Meretrix rostrata, Galerus mamillaris* and *Trophon laciniatus* (the variety *inornatus* of the latter is comparatively rare). *Ostrea ingens,* although very abundant, is not characteristic.

Aside from the incompleteness and incorrectness of the paleontological characters as given by Ameghino, how is it at all possible to place these beds where he does within his scheme? What does Ameghino know about the relation of the Cape Fairweather beds to the Lower Tehuelche and the Ensenadense beds? Does he possess any evidence on this point beyond that furnished by Hatcher? These are questions to which an answer is requested, and, unless Ameghino gives satisfactory explanation, we cannot put any faith in his stratigraphic reference of the Cape Fairweather beds.

A second instance is Ameghino's treatment of the 'Arenaense' formation. This he puts into the Upper Eocene, on top of the 'Superpatagoniense,' and below the Oligocene 'Paranense,' and mentions seven characteristic fossils.

This formation, no doubt, has been created to receive the uppermost marine horizon discovered by Hatcher near Punta Arenas, from which I have described seven species; but the latter do not correspond to those mentioned by Ameghino. Five of the species of my list are also found at the type locality of the Patagonian beds at Santa Cruz (see Ortmann, *l. c.*, p. 280), and, consequently, I have drawn the conclusion that these beds are contemporaneous. Of these five species, not a single one has been mentioned by Ameghino by name, and only three *de facto,* but under different names (*Ostrea ingens* as *O. philippi, Crepidula gregaria* as *C. imperforata,* and *Sigapatella americana* as *Trochita colchaguensis*). The other two (*Glycimeris ibari* and *Lucina promaucana*) have been left out entirely, and further, *Venus chiloënsis* is not mentioned, and *Meretrix iheringi* is removed into the horizon below (as *Cytherea splendida*). In their place, Ameghino adds four other species: *Cardium magellanicum, Modiola schythei, Venus rodriguezi,* and *Psammobia darwini.* These are taken from Philippi's list of fossils found near Punta Arenas:* some of the species of this list have been rediscovered by Hatcher, but they are found in different horizons here, partly above, and partly below the Punta Arenas coal. Thus it is impossible to say of any of the other species that have not been collected by Hatcher, whether they belong to the 'Arenaense' beds, or to the 'Magellanian,' by which name we have called the beds below the coal. And further, why does Ameghino select only these four species out of Philippi's list, while there are four more which are entitled to the same consideration?

These two instances may be sufficient. I shall not discuss the age assigned to the respective beds by Ameghino, although Stanton† and myself have devoted much time and labor to this question, and our final results are at

* This percentage is of no value at all on account of the small number of species.

† This very characteristic form described by myself for the first time from Cape Fairweather, which, consequently, is its type locality and formation, is removed by Ameghino from its association with the other 'Fairweatherense' fossils, and mentioned as characteristic for the horizon below, the 'Lower Tehuelche.' There is no excuse whatever for this arbitrary change of facts, and this course cannot be too strongly condemned.

* Philippi, R. A., 'Die tertiaeren und quartaeren Versteinerungen Chiles,' 1887, p. 251.

† 'Rep. Princeton Univers. Exped. Patagonia,' Vol. 4, Part 1, 1901.

variance with Ameghino's. When he places the marine Cretaceous beds of the lower Rio Tarde section in the Neocomian, while Stanton declares them not older than Gault, and when he places the marine Patagonian beds in the Eocene, while I assign them to the Lower Miocene, he can do so only if he introduces new evidence, and shows that our determinations are incorrect. But he has not done this, and has never attempted to do it, and therefore his personal opinion on this question is without any scientific value.

Ameghino may claim that my final report on the Tertiary invertebrates had not come into his hands when he wrote the present paper. But he must have seen Stanton's report, as well as the preliminary notes by Hatcher and myself in the *American Journal of Science*. These should have induced him to wait for the publication of my final report.

DR. A. E. ORTMANN.

PRINCETON UNIVERSITY,
September, 1902.

VELOCITY OF LIGHT IN AN ELECTROSTATIC FIELD.

TO THE EDITOR OF SCIENCE: In a paper, 'Determination of the Electric and Magnetic Quantities,' *Phys. Rev.*, January, 1900, I pointed out that light should be accelerated in an electrostatic field. I have to announce that preliminary experiments made last year show that this is the case, though the velocity actually observed is only eighty per cent. of that predicted in the paper referred to.

The tests. however, were rough and can be made more accurately with improved apparatus. I am desirous of repeating them, and obtaining a closer result. I would be glad to know of any one who has worked on interference phenomena who would be willing to collaborate with me, I of course bearing all expense.

In a recent note to the Toronto Astronomical Society, I refer to a paper to be published in SCIENCE, in which I show that by a development of the vortex theory described in the above-mentioned paper, the difference between positive and negative electricity is explained. By some mishap this paper was lost in the mails, about last December, and merely the letter forwarded with it reached the editor. I hope to rewrite it, but at present would say that I found that the difference is merely one of circulation, *i. e.*, that the simple vortex singularity must be taken as the negative electron, and that when a number of the vortex singularities are so grouped that their circulation is closed, they behave as positive electrons. Hence the positive electron is simply an agglomeration of negative electrons, so grouped as to have a closed circulation.

REGINALD A. FESSENDEN.

SHORTER ARTICLES.

THE FORMATION OF DEWBOWS.

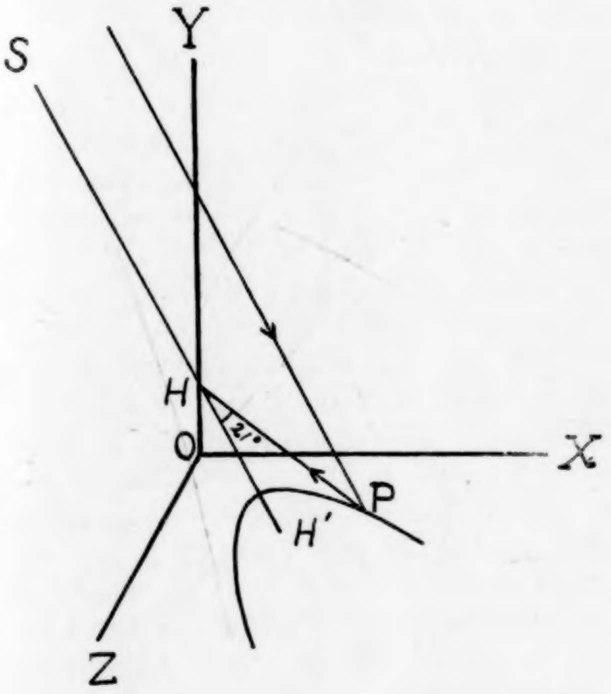
IF an observer standing on a mountain top should view below him, under suitable conditions, a horizontal stratum of falling raindrops on which the sun was shining, he would see a rainbow. This bow would appear as a true circle, or a segment of it, depending upon the area of the stratum and the position of the sun. If, however, he could view this bow with reference to its *space* relations, he would no longer see a circle, but some other conic section. This latter condition was recently observed to be satisfied by the reflection and refraction of sunlight in the drops of dew on a lawn. The phenomenon appears to be unique, and furnishes another interesting modification of the familiar rainbow.

The space in front of one of the Government buildings had been recently harrowed and then carefully leveled and rolled, and finally seeded thickly with Kentucky blue grass. At the time the observations were made this grass was about one and a half centimeters high, covering the ground thickly, and very uniform in height, the fine spears being surmounted with drops of dew.

On standing with one's back to the sun, one could see the bow on the grass very distinctly, which at nine o'clock A.M. was at a distance of about one meter at its nearest point, and then extended on either side in the form of a conic, to a distance of from ten to fifteen meters. The red color of the outer portion of the bow and the blue of the inner side were well de-

fined, although the boundary between the two was somewhat indistinct. There was, however, no question whatever about the existence of the definite colors.

The appearance of the bow may, perhaps, be better understood by reference to the accompanying figure in which the XZ-plane represents the ground, while the observer is standing at the origin, his head being at H. The shadow of the observer's head would then fall upon the plane at XZ at H', and the bow appeared on the ground between the feet of the observer and the shadow of his head, and extended on either side in the manner indicated in the sketch.



Assuming the simple explanation of the rainbow to apply in this case, the figure of the bow would be given by the intersection of the XZ-plane with the 42° cone (red rays), generated by the rotation of the line HP about SHH' as an axis, at an angle of 21°. The form of the bow is, of course, dependent upon the altitude of the sun. With the sun at the horizon, and for altitudes up to 21°, the figure would be a hyperbola; at 21°, it would be a parabola. At altitudes of the sun above 21°, we would have an ellipse, becoming a circle at the zenith with its center at the origin of coordinates.

The phenomenon was readily observed on the morning succeeding the first observations, but three days later, when another heavy dew appeared, no trace of the bow could be seen. During this time the grass had grown considerably, and the irregularity in height appeared to prevent the reflection of a sufficient amount of light. The existence of the bow has not yet been noted on any lawn on which the grass has attained considerable size.

LYMAN J. BRIGGS.

WASHINGTON, D. C.

NOTES ON INORGANIC CHEMISTRY.

CENSUS BULLETIN OF CHEMICALS AND ALLIED PRODUCTS.

THIS 'Bulletin,' prepared by Professor Charles E. Monroe and Dr. T. M. Chatard, which has just been issued, is extremely interesting reading and is full of valuable information. It is in effect a brief review of the chemical progress of this country in the last decade, with glimpses of the progress elsewhere, when this would seem to have a bearing upon possible future development here. Thus are treated at some length the catalytic production of sulfuric acid, the manufacture of soda from the natural soda of the West, wood distillation, fertilizers, explosives, and particularly chemical substances produced by the aid of electricity. It is interesting to note that the value of the principal products reported in this 'Bulletin' is \$221,217,217 as compared with \$163,547,685 reported in the census of 1890. Except in the potash industry, which is insignificant, there has been an increase in every department, but hardly as great as might have been looked for, considering the greatly increased attention given to the application of science to industry. Possibly this is more readily understood from the statistics of chemists employed in the establishments treated of in this report. From this it appears that the total number so employed in the United States is 276, about half the number employed by six coal-tar color firms of Germany. The largest number employed in any one industry is 52, in paints and varnishes. Those in the coal-tar products number 7, to which should prob-

ably be added a part of the 13 engaged in the dye-stuff industry.

Among all the industries, the largest percentage of increase has been in that of wood distillation, including the production of wood alcohol, acetate of lime, and charcoal. The increase was from $1,885,469 in 1890 to $5,775,455 in 1900. This is, however, by no means so significant as the statistics of the soda industry, which increased from five million dollars in 1890 to over ten millions in 1900. Owing to lower price, this represents nearly a quadrupling of production. What is more important in this industry is that this country is now practically independent of foreign supply. In 1890, 60 per cent. of the soda ash and sal soda and over 70 per cent. of the caustic soda used were imported, while in 1900 only 9 per cent. of the former and less than 5 per cent. of the latter were manufactured abroad.

Considerable emphasis is laid in the 'Bulletin' on the possibilities of the alkali lakes of the Sierra Nevada as a source of supply. The production from this source has been restricted by the lack of a market, owing to the cost of transportation. With the development of the industries of the Pacific slope, and the demand from the other side of the Pacific Ocean, it is probable that these remarkable supplies can be utilized to a much greater extent than in the past. Mono Lake alone contains enough soda to supply this country at its present rate of consumption for a hundred years, Owens Lake enough for fifty years, while other smaller lakes could considerably more than double this amount.

Nearly one half of the 'Bulletin' is taken up with a 'Digest of Chemical Patents,' giving an abstract of all chemical patents issued from the founding of the United States Patent Office up to 1900. This was prepared by Mr. Story B. Ladd, and is of great value. Its value would be still more increased if it could be carefully indexed by subject and by patentee, and issued as a separate publication.

In this connection it is worth while to note that the 'Bulletin' calls attention to the inequitable patent laws of this country, by which a foreigner can, by obtaining an American patent, enjoy the monopoly of sale in this country, even though the article in question may be manufactured abroad, and owing to competition may be sold at a low price everywhere else in the world (except in England, whose laws in this respect resemble ours). On such an article the tariff serves only to increase the price to the American consumer, who is by the patent prevented from enjoying any benefit from competition. This is undoubtedly the chief reason which has hindered the development of most chemical industries in this country except those of the heavy chemicals. J. L. H.

BOTANICAL NOTES.

A WORD AS TO INDEXES.

It is time that reform was made in the indexing of botanical books. There appears to be an impression among index-makers that people want their indexes sorted into various kinds, so that we find, for example, an 'index of illustrations,' an 'index of English names,' an 'index of Latin names,' an 'index of synonyms,' etc. If this thing goes on we may have, in addition to the foregoing, indexes of the names of persons cited; indexes of experiments, descriptions and discussions; indexes of original paragraphs; indexes of second-hand paragraphs, etc. Probably nearly every user of books will agree that more than one index is a nuisance. When one takes up a book to look for Mahonia it is awkward and annoying to find that it is not in the 'index of Latin names' but must be sought in the 'English index.' How is one to know where to look for Sapodilla, and Sassafras? In some recent indexes the first is given in the English index, while the second occurs only in the Latin index.

It may be said that after all our inveighing against indexlessness we ought to be doubly thankful for two indexes, instead of making complaints, but here, as elsewhere, it is possible 'to have too much of a good thing.' Let not the book-maker, in his zeal to avoid indexlessness, inflict upon his readers an evil which is only one remove from that in its power of annoyance. Give us a good index, and let

it include everything which it is desirable to list, but do not make separate indexes.

THE PRESERVATION OF WILD FLOWERS.

THE movement to preserve the wild flowers from the destruction which threatens them at the hands of thoughtless persons has taken form, and we may now hope for some definite results. It is not true that the people are indifferent to the fate of the wild flowers; they are merely ignorant as to any threatened danger. When once they find that certain pretty plants are in danger of extermination they are ready enough to act. In the vicinity of Colorado Springs, Colo., the 'tourists' have for years been at work eradicating the more conspicuous plants from the canyons which they visit in swarms. In some of these canyons one can now find but few of the pretty plants which once abounded there, and it has been a constant source of irritation to lovers of nature visiting these places to see these vandals clutching every beautiful thing within reach. At last the residents of Colorado Springs have waked to the fact that their treasures have been stolen, and they are now organizing for the purpose of protecting those that remain. Every 'summer resort' has suffered in like manner, and it will be necessary for the permanent residents to follow the example of Colorado Springs if they hope to preserve the plants which adorn the landscape. Wherever the feeling has arisen that such work must be done, those interested should at once consult with Charles L. Pollard, Secretary of the Wild Flower Preservation Society of America, at Washington, D. C.

THE SHRUBS OF WYOMING.

IN a recent bulletin of the Wyoming Experiment Station, Mr. Elias Nelson enumerates the shrubs of the state, and gives such popular descriptions as will serve to distinguish the species. One hundred and five species are included, of which five are Gymnosperms (of the genus *Juniperus*) the remainder being Dicotyledons. No Monocotyledons are included, apparently indicating that there are no woody species in Wyoming. In the list there are thirteen willows (*Salix*); five species of chenopods (*Chenopodiaceæ*); nine of currants and gooseberries (*Ribes*); five roses (*Rosa*); four honeysuckles (*Lonicera*); five sage-brushes (*Artemisia*); and ten rabbit-bushes (*Chrysothamnus*). No less than eighteen species of Compositæ are more or less shrubby.

There is but one shrubby species of the pea family (*Papilionaceæ*), namely the false indigo (*Amorpha fruticosa*). So there is but one shrubby dogwood (*Cornus stolonifera*). Of the heaths and their allies only three species are given.

On comparing this list of the shrubs of Wyoming with Professor Aven Nelson's 'Trees of Wyoming' published two or three years ago, we find that of the thirty-one trees there given no less than twelve are here introduced as 'shrubs.' However, all these are on the border line between trees and shrubs, and it is perhaps better to list them twice than to permanently assign them to one or the other class. In the flora here represented there are about one hundred and twenty-four species of woody plants, of which less than one sixth are certainly to be ranked as trees. This predominance of shrubs is a notable feature of the woody vegetation of the highlands of the West.

AN OLD BROWN CEDAR.

IN the Garden of the Gods, near Pike's Peak, Colo., there are many large specimens of the brown cedar, *Juniperus monosperma* (Engelm.) Sargent, and in a recent visit to that place it occurred to the writer that these trees must be very old. On the 13th of August he was fortunate enough to find the stump of a recently cut tree, on which it was easy to distinguish the annual growth-rings. These were counted for a section of the trunk, care being taken to select a portion in which the rings were of average thickness, and on this basis the number for the whole stump was calculated. In this way it was found that this particular tree was between eight hundred and one thousand years old. In other words, this tree was a seedling some time between the years 900 and 1100 A. D.

CHARLES E. BESSEY.
THE UNIVERSITY OF NEBRASKA.

SCIENTIFIC NOTES AND NEWS.

The University of Christiania has on the occasion of the centenary of the birth of Abel conferred honorary degrees on a number of mathematicians, including Professor Simon Newcomb and Professor J. Willard Gibbs.

Dr. Emil Fischer, professor of chemistry at Berlin, and Dr. Carl von Voit, professor of physiology at Munich, have been elected corresponding members of the Vienna Academy of Sciences.

Brigadier-General Robert M. O'Reilly assumed the duties of surgeon-general of the army on September 8.

Major Ronald Ross, of the Liverpool School of Tropical Medicine, expects to visit the United States to study malaria.

Mr. Robert T. Hill, of the Geological Survey, who was recently sent to Martinique to investigate the eruption of Mt. Pelée, will be engaged this season in an investigation of the Trans-Pecos region of Texas, Arizona and New Mexico. Dr. G. H. Girty, paleontologist, will be associated with Mr. Hill in the work.

Dr. Ludwig Biro, who has spent six years in making zoological and ethnographic studies in the Malay archipelago, especially in New Guinea, has returned to Buda Pesth.

M. Boris Fedtschenko has returned from a scientific expedition to the elevated Pamir desert with a collection of plants.

Dr. Lukjanoff, professor of pathology at the University of Warsaw, and director of the Institute of Experimental Medicine in St. Petersburg, has been appointed deputy minister of public instruction by the Russian Government.

M. de Gerlache, leader of the recent Belgian antarctic expedition, has been appointed curator in the Natural History Museum at Brussels.

Dr. J. B. Messerschmitt, of Hamburg, has been appointed observer in the electro-magnetical laboratory connected with the observatory at Munich.

Dr. A. Slaby, professor of electro-mechanics in the Technical Institute at Charlottesburg, has received for his researches 20,000 Marks from the fund for German industry. Dr. K. von Linder, professor of thermodynamics at the Munich Technical School, has received 10,000 Marks from the same fund.

Dr. Alex. P. Anderson has resigned his position of curator of the herbarium of Columbia University to become an expert to the syndicate now engaged in developing the new method of treating starchy grains, etc., recently discovered by Dr. Anderson in the laboratories of the New York Botanical Garden. Dr. Anderson is fitting up a laboratory for the continuance of his work at Minneapolis.

A memorial has recently been erected by the German Association of Alienists over the grave of the anatomist, Reil. He was buried in his garden at Halle, which is now part of the Zoological Gardens of the city.

Professor Rudolf Virchow was given a public funeral by the city of Berlin on September 9. Services were held in the City Hall, addresses being made by representatives of the Reichstag and the Town Council, and by Dr. Wilhelm Waldeyer, professor of anatomy in the University of Berlin. The body was buried in St. Matthew's Cemetery, which is situated in a southwestern suburb of Berlin.

Sir Frederick Abel, known for his important researches on explosives, died on September 8, at the age of seventy-six years. He was one of the most prominent British men of science, having been president of the British Association for the Advancement of Science, the Iron and Steel Institute, the Chemical Society, the Institute of Chemistry, the Society of Chemical Industry, and the Institute of Electrical Engineers, and chairman of the Society of Arts.

Cablegrams to the daily papers state that the British Association for the Advancement of Science opened its seventy-second annual meeting at Belfast on September 10, when Professor James Dewar made his presidential address. The Association has been invited to meet in South Africa in 1905. It is said the colonial governments have offered to contrib-

ute $35,000 towards treveling and other expenses.

THE Chillean Government has issued orders that all possible facilities be furnished to the expedition from the Lick Observatory, which will shortly begin its work in that country.

THE American Institute of Mining Engineers will hold its eighty-third meeting at New Haven, Conn., beginning on Tuesday, October 14, 1902.

THE English Arboricultural Society held its annual meeting in London on August 18. Mr. George Marshall, member of the Royal Forestry Commission, was elected president in succession to Dr. Somerville, of the Board of Agriculture.

THE annual conference on the improvement of the condition of the insane, which met recently at Antwerp, adopted the following resolutions: (1) That the confinement of the insane henceforth be abandoned except in the cases of those recognized as dangerous. (2) That the system of boarding insane persons with families be carried out whenever possible. (3) That it is expedient to renew the wish formulated at the Congress at Paris for the establishment of schools for special classes of the mentally weak under medical supervision. (4) That the manner of placing patients be entirely left to physicians. (5) That forcible restraint should be condemned.

A LARGE table, invented by Professor E. C. Pickering, has been constructed in the north building at the Harvard Observatory. It is made in two revolving sections, one above the other, and takes the place of six separate tables used before. In the upper section the annals of the observatory, magnifying glasses, and reference books are kept; in the lower, letters and files.

THE division of mining and mineral resources of the Geological Survey, under Dr. D. T. Day, has issued a chart showing the quantity and value of the mineral productions of the United States for the ten years ending with 1901. The value of the total output of metallic ores, such as iron, copper, gold, silver, etc., in 1901 was $524,873,284, against $307,936,189 in 1892; and the value of the nonmetallic products, including coal, petroleum, natural gas, building materials, etc., was $566,351,096 in 1901, against $339,958,842 in 1892. From the arrangement of the metallic and nonmetallic resources on a single sheet, it is possible to follow the yearly change in the production of about sixty of the important mineral products of the country during the decade. The chart, to be had on application to the director of the United States Geological Survey, is issued in advance of the report, 'Mineral Resources of the United States, 1901,' which will be ready for distribution in the fall.

FOREIGN papers report that the vessel *Antarctic,* of the Swedish South Polar expedition, with five scientific members, left Port Stanley, in the Falkland Islands, on April 11 for South Georgia. The expedition stayed in South Georgia from April 22 to June 15, and during this time a detailed survey was made of Cumberland Bay, one of the largest bays in South Georgia. Investigations into the natural history of Cumberland Bay were carried on, and zoological collections brought home from depths as great as 2,700 meters. Soundings have given depths up to 5,997 meters northwest from South Georgia. The expedition returned to Port Stanley on July 4, and will up to the end of September carry on work around the Falkland Islands and in Tierra del Fuego. In October the *Antarctic* will start for Graham Land, in the Antarctic Ocean.

THE English journals announce that the following prizes have been awarded for essays on subjects connected with tropical diseases:—(1) A prize of the value of 10*l.*, entitled the Sivewright prize, presented by Sir James Sivewright for the best article on 'The Duration of the Latency of Malaria after Primary Infection, as proved by Tertian or Quartan Periodicity or Demonstration of the Parasite in the Blood,' awarded to Dr. Attilio Caccini, assistant physician, Hospital of Santo Spirito in Sassia, Rome. (2) A prize of the value of 10*l.*, entitled the Belilios prize, presented by the Hon. E. R. Beililios, C.M.G., for the best article on 'The Spread of Plague from Rat to Rat, and from Rat to Man by the Rat-flea,' awarded to Dr. Bruno Galli-

Valerio, professor in the University of Lausanne, Switzerland. The prize of the value of 10*l.* entitled the Lady Macgregor prize, presented by Lady Macgregor for the best article on 'The best Method of the Administration of Quinine as a Preventative of Malaria Fever,' was not awarded. The judges were Surgeon-General Roe Hooper, president Medical Board, India Office, Colonel Kenneth MacLeod and Mr. Patrick Manson, F.R.S.

Mr. Cuyler Reynolds, curator of the Albany Institute and Historical and Art Society, and chairman of the committee to collect funds for a meorial to Joseph Henry, has sent the *Electrical World* the following resolution:

That this committee favors a memorial wherein the sciences shall be taught, in connection with the Albany Academy where he taught as a member of the faculty, and within which building he performed the experiment that demonstrated the correctness of his principle of the electric telegraph, believing that it will be more practical than any other type; and thereby holding in cherished remembrance the views and character of the one who has been long recognized as the leading American scientist, and who donated his discoveries to the advancement of knowledge and the world's industries.

Considering the inestimable advantage that the inventions of Joseph Henry have been to the world, inasmuch as the sum of $4,000,000,000 is invested in this country alone in enterprises that his study and free gift made possible, which industries give employment to more than a million persons, and appreciating the honor of his labors in connection with the work of this organization, we take this step with a feeling that even when the efforts shall be crowned with success it will be but a slight token of the sincere esteem of the country.

UNIVERSITY AND EDUCATIONAL NEWS.

The University of Montana is erecting a woman's hall, to accommodate about 70 students, and to cost about $35,000. The building will be ready for use by the first of January, 1903. That portion of Science Hall recently destroyed by fire has been rebuilt, with additional space for a school of pharmacy, not yet organized. The foundation is laid for a gymnasium to cost $10,000.

Vassar College receives $10,000 by the will of the late Adolph Sutro, of San Francisco.

The Wilson endowment fund of $100,000 for Washington and Lee University being made up, Mr. Herbert Welsh, of Philadelphia, who was largely instrumental in raising it, recommends that a fund of $500,000 be collected to endow a scientific and technical school for the university.

The four hundredth anniversary of the foundation of the University of Halle, formerly at Wittemburg, will be celebrated on November 1, when a new auditorium building will be dedicated.

A parliamentary committee has made a report of the finances of Melbourne University, from which it appears that the university has lost about $120,000 through the frauds of an accountant. As the defalcation was in part due to the carelessness of the government auditors, the committee recommends that the loss be made good by the government.

Dr. H. J. Wheeler, director of the Rhode Island Agricultural Experimental Station and professor of geography and geology in the college, has been appointed acting president. President Nichols, of the Kansas Agricultural College, at first accepted and then declined the presidency.

Henry Farnham Perkins, Ph.D. (Johns Hopkins), has been appointed assistant professor of biology in the University of Vermont.

The following changes have been made in the department of physics of the University of Nebraska: Mr. Chas. M. Heck, A.M. (Columbia, 1901), has been appointed fellow in physics vice Mr. W. B. Cortmel, who has resigned to accept appointment with U. S. Bureau of Standards, Washington.—Mr. John Mills (Chicago, 1901), fellow in physics vice Mr. S. B. Tuckerman, has been appointed instructor in physics, University of Ohio.—Mr. S. R. Cook, former fellow in physics, has been appointed instructor in physics in the Case School of Science, Cleveland.

Dr. George T. Patton has been elected professor of moral philosophy at Princeton University.

SCIENCE

John Wesley Powell, eminent in anthropology and in geology, director of the United States Bureau of Ethnology, formerly director of the United States Geological Survey, past president of the American Association for the Advancement of Science, one of the editors of this journal, died on September the twenty-third.